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No. 134. Vol. 20.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.

THE ONE HUNDRED AND SIXTIETH GENERAL MEETING of the Institution of Petroleum Technologists was held at the Royal Society of Arts, John Street, Adelphi, W.C. 2, on November 13th, 1934, Mr. T. DEWHURST, the President, occupying the Chair.

The Secretary read the list of candidates nominated for membership, and the following list of members elected :—

As Members.—Charles Thomas Berry, Alfred Reginald Code, Ernest LeQuesne Herbert, Wilfred Hermann Hoffert, James Hector MacDonald, Mrs. Boleslawa Elzbieta Mielnikowa, Federico Plate, Edwin John Sims, Herbert Cubitt Gostling Vincent.

As Transfer to Members.—Cecil Chilvers, Eric Bertram Evans, Gerald Hugh Scott.

As Associate Members.—William Lyall Barr, Thomas Bedford, John William Hardy, John Franklin Turpie.

As Transfer to Associate Members.—William James Baker, Ernest Clark, Eric Edwin Manning, Abbas Parkhideh, Alfred Leonard Read, Neville Edward Rocca Tayleur, Alfred Wilson.

As Students.—Jack Blatchley Harrison, Frederick George Parmenter.

As Associate.—John Fletcher Miller.

The President stated that the election of the President of the Institution was governed by the By-laws, of which Section VII., No. 3, laid down, *inter alia*, that the President shall be elected by the members of the Council, and that the election shall take place prior to each Annual General Meeting. In recent years it had been customary for the Council to elect the President some months in advance of the Annual General Meeting, and he had pleasure in announcing that in accordance with this custom the Council had unanimously elected Sir John Cadman, G.C.M.G., Hon. LL.D., D.Sc., as President for the year 1935–36, to take office immediately after the Annual General Meeting to be held on March 12th, 1935. (Applause.)

The main business of the present meeting, continued the President, was to hear a paper entitled "The Utilisation of Petroleum Products as Horticultural Spray Materials," by H. Martin, D.Sc., F.I.C., of the Long Ashton Agricultural and Horticultural Research Station, Bristol. Dr. Martin was a well-known expert in this subject and fortunately was present with them that evening to read his paper.

The Utilisation of Petroleum Products as Horticultural Spray Materials.

By HUBERT MARTIN, D.Sc., F.I.C.*

SUMMARY.

1. The employment of petroleum oils as spray insecticides is discussed and an example is given of the methods used for the correlation of insecticidal activity and the chemical and physical characteristics of the oil.

2. The results of critical laboratory and field trials are quoted in support of the conclusion that the ovicidal and insecticidal properties of petroleum oil sprays applied to dormant trees are independent of the base of the oil, of its viscosity over the range 126 secs.–870 secs. Redwood I. at 70° F., of its degree of refinement over the range represented by unsulphonated residues of 60–100 per cent. by volume, and of the type of emulsification.

3. The petroleum oils suitable for application to foliage are limited to the highly refined oils of a viscosity high enough to ensure satisfactory insecticidal properties.

4. Evidence is given that the insecticidal properties of oil sprays applied to foliage decreases as the stability of the emulsifier is increased. The selection of suitable emulsifiers for the preparation of oil sprays to be used in combined sprays is discussed.

5. The action of petroleum oils in increasing the efficiency of companion insecticides and fungicides in combined sprays is described in connection with the properties of oils as "stickers" and "spreaders."

6. Concerning the possible utilisation of certain petroleum products as soap substitutes, the naphthenic acids are shown to be unsatisfactory. The sulphonic acids produced during acid refinement include :—

(i) the gamma-acids, of which the calcium salts are water soluble and are promising spray materials, and

(ii) the beta-acids, of which the calcium salts are insoluble but of which the acids and sodium salts are relatively oil-soluble and of possible use as emulsifiers.

SINCE the first use of kerosine for the control of fruit tree pests in the latter half of the last century, and following the development of applied biology and the extension of the range of oils used to the higher-boiling fractions, petroleum oils of the lubricating oil class now form a valuable and widely used insecticide. In addition, the oils and derivatives such as the petroleum sulphonic acids have been found to supplement the insecticidal and fungicidal properties of certain other spray materials, and there is an increasing use of such products as spray adjuvants.

For the discussion of the use of petroleum oils as active insecticides, it is convenient to differentiate between oils intended for application to deciduous crops during the dormant season and oils applied to foliage. The former preparations are usually termed winter washes, their purpose being the destruction of hibernating pests and insect eggs.

*Long Ashton Agricultural and Horticultural Research Station Bristol.

Winter Washes.

In this country the petroleum oil winter washes were introduced about 1929 mainly for use as egg-killing or ovicidal sprays. Field experience has since shown that against the eggs of certain pests such as the geometrids (winter moths), capsids and acarids (red spider), the petroleum oil preparations are generally more effective than the tar distillate washes, introduced as winter washes some eight years earlier. The tar oil washes are, however, extremely toxic to eggs of aphids and psyllids, pests against which the petroleum oils appear deficient in ovicidal properties.

The successful development of any insecticide or fungicide is dependent on the discovery of the factors responsible for and influencing its biological activity. Thus, with the petroleum oils, it becomes necessary to determine with what chemical and physical properties of the oil insecticidal properties are associated, so that selection of oils most suitable for a specific spray purpose becomes possible. It was with this object in view that an investigation was begun in the winter of 1930-31 at the South-Eastern Agricultural College, Wye.[1,2,3] Laboratory and field trials were carried out with sprays prepared from oils of known characteristics by the same emulsification process and under controlled experimental conditions.

For the laboratory trials the test organisms used were the eggs of the Common Green Capsid Bug (*Lygus pabulinus*), a notorious pest of both black and red currants. The eggs are inserted into the tissue of the young shoots, and as the proper development of the egg is probably dependent upon the normal growth of the shoot, a special technique was necessary to facilitate treatment. Twigs from groups of red currant bushes known to be heavily infested were collected at pruning and placed in damp sand until required for treatment. At the end of January suitable twigs were selected at random and immersed, apex downwards, in the oil emulsions, withdrawn and placed to dry on a rack so arranged that no drainings collected in drops in contact with the twig. When dry the twig was freshly cut at the base in case the emulsion had soaked into the exposed tissue. The treated cuttings were then placed in small pots of damp sand, five per pot, the pots being sunk in a bed of sand and left exposed to the weather.

Under these conditions the majority of the twigs developed normally and, towards the end of April, the pots were brought into an unheated greenhouse and the rim of each pot coated with a grease-banding composition to prevent migration of the capsids from one pot to another. During the hatching period the twigs

were examined twice daily and any capsids present removed and counted. Finally, when hatching had ceased, the cuttings were examined, the bark being peeled and the number of hatched and unhatched eggs per twig counted. In each year the number of hatched eggs found on peeling the twigs was found to correspond exactly to the number of capsids removed from the twigs.

In all trials, except those made to determine the influence of type of emulsification upon ovicidal properties, the oils were emulsified by the two-solution oleic acid method.[16] In this method a standard amount of oleic acid was dissolved in the petroleum oil and the solution added to dilute sodium hydroxide solution, each spray containing 0·6 per cent. of oleic acid and 0·1 per cent. sodium hydroxide. Distilled water was used, and all the oils examined gave good emulsions by this method, except an oil of high viscosity (4500 secs. Redwood I. at 70° F.), which, being too viscous for practical use, was used only in one year's trials. To avoid errors due to possible creaming the emulsion was shaken frequently throughout the dipping of the twigs.

Tests were also made of the influence of variety of currant on the ovicidal behaviour of the oils, and, in 1933 and 1934, sets of ten twigs of two varieties were used in each test. As no difference in ovicidal efficiency due to variety of currant was observed, the results of counts have been combined in Table I., which gives the results per 20 twigs expressed as the number of hatched eggs/the total number of eggs found. Twigs which failed to root and on which the buds did not break normally were omitted from the counts. Control tests made with untreated twigs and with twigs dipped in the sodium oleate solution used as emulsifier showed that normal hatching proceeded under the experimental conditions. Thus, in 1933, 100 twigs of the variety Fay's Prolific contained 152 eggs, of which all except one hatched, and of 100 twigs of the variety Versailles all the 90 eggs present hatched.

With the results of counts given in Table I. are included certain characteristics of the oils tested, together with particulars of the base of the oils as given by the refiner. The specific gravity and viscosity of the oils were determined by the standard methods, the boiling range and percentage unsulphonated residue were estimated by the methods given by Austin, Jary and Martin.[1] A detailed statistical examination based on the assumption that the eggs are of a uniform population and ignoring experimental error reveals significant differences in ovicidal properties within each year's results,[1,2,3] but in no case does an oil show consistently superior or inferior ovicidal action. Thus in the 1932 results the oils P11 and P13 stand out as markedly inferior to the neighbouring oils, but this difference is not shown either in the 1933

TABLE I.

Oil No.	Base.	Sp. gr. 60° F.	Viscosity Redwood I. @ 70° F. Seconds.	Boiling range by volume. 10% ° C.	50% ° C.	80% ° C.	Unsulphonated residue. % by vol.	Ovicidal action.† 1932. 5%	3%	1933. 4%	2%	1934. 4%	2%
L2	Asphaltic	0·886	127	320	354	390	97·9	3/34	4/27	2/23	8/14	—	—
L3	,,	0·864	126	321	359	386	96·4	0/26	0/33	0/18	24/24	—	—
L4	,,	0·885	357	355	390	—	96·7	0/26	11/28	4/28	12/14	—	—
L5	,,	0·864	136	325	361	391	96·1	0/40	0/31	0/33	1/13	—	—
L6	,,	0·885	800	384	—	—	100·0	0/38	2/32	1/19	4/14	—	—
P2	,,	0·898	166	346	377	—	64·7	0/24	3/29	3/16	13/24	—	—
P3	,,	0·875	157	326	362	398	81·8	0/36	0/29	4/21	11/15	1/46	19/23
P4	Mixed	0·898	160	346	375	—	64·6	0/28	7/27	1/33	12/16	2/33	33/42
P4a	,,	0·898	167	348	377	—	74·2	—	—	2/17	6/14	3/51	42/54
P5	Asphaltic	0·938	4500	392	—	—	*80·0	0/30	8/24	—	—	—	—
P6	Paraffinic	0·887	210	368	388	—	72·8	0/30	1/28	6/12	8/9	3/33	7/22
P7	,,	0·891	289	374	397	—	75·4	0/27	0/36	2/21	2/14	—	—
P8	,,	0·896	420	387	—	—	73·7	0/25	0/31	0/33	9/16	—	—
P9	Naphthenic	0·888	234	349	387	—	88·8	0/33	0/31	0/18	7/8	—	—
P10	,,	0·902	524	373	—	—	81·5	0/30	0/30	1/14	16/17	0/36	14/19
P10a	,,	0·905	542	366	—	—	86·7	—	—	1/18	4/14	2/32	25/37
P11	,,	0·905	720	378	—	—	80·0	0/25	8/24	1/24	6/10	6/40	12/23
P12	Western	0·897	167	344	375	—	68·9	0/22	0/24	1/18	14/20	—	—
P12a	,,	0·897	168	345	378	—	73·3	—	—	0/29	2/7	—	—
P13	,,	0·913	298	347	383	—	62·4	0/35	11/30	0/13	19/19	0/47	19/32
P14	,,	0·913	420	365	—	—	*58·0	0/18	0/21	2/19	6/11	—	—
P17	Asphaltic	0·931	870	381	—	—	58·3	—	—	2/32	20/22	—	—

* Oil layer imperfectly separated from oil layer. † Expressed as eggs hatched/total eggs.

or 1934 trials. The oil P6 also would be judged deficient in ovicidal properties on the basis of the 1933 results, a deficiency not shown in the 1932 or 1934 results.

It has thus proved impossible to detect any general difference in ovicidal properties between the twenty-one oils examined, and we may conclude that ovicidal activity is independent of the base of the oil, of viscosity over the range 126–870 secs. Redwood I. at 70° F., and of unsulphonated residue over the range 60–100 per cent. by volume. This conclusion is supported by the results of field trials in which, among others, the oils L2, P2, P4a, P10a and P12a were used, and in which no indication of consistent differences in general ovicidal properties was obtained.

In addition to knowledge of the chemical and physical properties of a suitable petroleum oil for use as an ovicide, information was also required of the influence of method of application upon biological properties, for the oils always are applied in practice in emulsified form. For this purpose, sprays prepared by the oleic acid method were compared, in laboratory and field trials, with sprays emulsified with Bordeaux mixture.[23] The oleic acid method yields stable emulsions of which the aqueous phase spreads readily over the sprayed surface; the Bordeaux emulsions break readily and spreading over the sprayed surface is accomplished by the oil so liberated. The results of the laboratory trials, given in Table II., show that no differences in ovicidal action due to type of emulsification were apparent.

TABLE II.

	Oleic acid emulsion.	Bordeaux emulsion.
4% L2	3/31	0/28
2% L2	4/23	11/21
4% L4	0/26	0/28
2% L2	11/17	3/30
4% P4	0/28	3/37
2% P4	7/20	5/22

The conclusions of our work at Wye are in agreement with the results of general experience and critical tests. Thus Melander, Spuler and Green[20] found that nine different oils of high boiling range had similar ovicidal properties to eggs of the fruit tree leaf-roller (*Cacoecia argyrosphila*) and, on the basis of four field trials, concluded that refinement was unnecessary above the stage represented by an unsulphonated residue of 50 per cent.[26] Against acarid eggs, Hamilton[12] reported that the kind of lubricating oil used was unimportant compared to thoroughness of application.

The insecticidal action of petroleum oils used in the dormant season against San José scale was examined by Swingle and

Snapp,[29] who used 21 oils of paraffin, naphthene and intermediate base, of viscosity ranging from 47 to 308 secs. Saybolt at 100° F., and of various degrees of refinement. Their trials indicated that oils above a certain minimum viscosity showed similar scalecidal activity, and, although obtaining indications that emulsions of the quick-breaking type were slightly more potent than stable soap emulsions, concluded that the difference was of no importance under field conditions. Newcomer and Yothers[21] also found that unstable casein and stable soap emulsions were of equal efficiency against San José scale.

The evidence at present available thus points to the conclusion that the ovicidal and insecticidal activities of petroleum oils, applied during the dormant season, are constant over a wide range of viscosity and degree of refinement and are independent of the type of emulsification employed.

Summer Washes.

In this country the application of petroleum oils to deciduous trees and herbaceous plants is confined mainly to the purpose of controlling red spider. In sub-tropical countries an important use is for the control of scale insects on citrus, and it is mainly for this purpose that critical scientific work has been carried out upon the biological properties of petroleum oils. The range available for summer use is limited to the highly refined oils, for Gray and de Ong,[9] de Ong, Knight and Chamberlin,[7] Green,[10] Tutin,[30] and others have shown that the derivatives causing acute foliage injury are removed by the refinement processes. The precise constituents responsible for foliage damage do not appear to be known with certainty. In addition to the acute type of injury, there is, however, a chronic type associated with metabolic disturbances and shown by such symptoms as the premature drop of leaves and fruit and, with certain crops, interference with water translocation causing the so-called "œdema" of the foliage. General experience and the critical work of Knight, Chamberlin and Samuels[15] indicate the severity of this chronic injury increases with the viscosity of the oil applied. Phytocidal properties thus limit the petroleum oils satisfactory for use as foliage sprays to highly refined lubricating oils of low viscosity. The insecticidal activity of such oils would appear from the work of Griffin, Richardson and Burdette[11] on *Aphis rumicis*, and of de Ong, Knight and Chamberlin[7] on the citrus scales to be constant, provided the oil is above a certain minimum viscosity. It is of interest to note that refinement, which de Ong[5] suggested might remove toxic constituents, was shown by Spuler, Overley and

Green,[27] and by Ebeling,[28] to have no effect upon insecticidal activity, an indication that this activity is due, not to chemical toxicity, but to a physical "stifling" action, such as Staniland, Tutin and Walton[28] postulated for the ovicidal action of winter petroleum oils. In contradistinction to the winter washes, critical experiment has shown that the type of emulsification employed has a marked effect upon the biological properties of the summer petroleum washes. de Ong and Knight[6] found that, in stable soap emulsions, from four to six times the amount of oil was required to yield the results obtained with the relatively unstable casein emulsions. This observation was confirmed by the later work of these investigators,[7] and by Griffin, Richardson and Burdette.[11] The increased activity of the unstable emulsions was correlated, in both studies, with the average oil droplet diameter which decreases with the stability of the emulsion. Similarly it was shown by Smith[25] and Ebeling[8] that the acaricidal efficiency of oil sprays decreased with increase of the amount of emulsifier present. Both effects are probably to be associated with the amount of oil deposited on the foliage, which is smaller the greater the stability of the emulsion.

The choice of the emulsifier is of importance in the summer petroleum oil washes not only because of its influence upon biological behaviour, but because it is often advantageous to incorporate other insecticides or fungicides in the spray. It is obvious that, in such combined washes, the emulsifier present must not contain constituents which interact, with detrimental consequences, with the companion materials. For example, if the emulsion is to be applied in combination with fungicides such as lime sulphur or Bordeaux mixture, soap or resinate emulsifiers are unsuitable because interaction with the calcium salts present causes the breaking or inversion of the emulsion with consequent application of a spray of non-uniform oil concentration. Oil emulsions for use in combination with lead arsenate, which is the most widely used of the stomach poisons, should contain no alkali salts such as soaps or ammonia-casein, otherwise there is danger of the formation of soluble arsenates, a known cause of foliage damage. Work on suitable emulsifiers for use in such combined washes, carried out at Long Ashton,[14] indicated that sulphite lye, a waste product from wood pulp manufacture,[17] was a satisfactory cheap emulsifier for use in petroleum oil preparations.

Oils and Petroleum Products as Spray Adjuncts.

Practical experience has shown that when used in combination with other spray materials, petroleum oils may contribute to the efficiency of the spray other than by their ability to act as insecti-

cides. With fungicides such as Bordeaux mixture, and stomach poisons like lead arsenate, of which efficiency is dependent on the retention of a protective deposit upon the foliage, the presence of the oil results in an improved retention. In localities where the application of arsenical sprays is necessary shortly before harvesting, and it becomes necessary to wash the picked fruit to reduce its arsenic content below tolerance limits, the use of lead arsenate-petroleum oil combinations gives a deposit so adherent that difficulties are met in spray residue removal.[27] A similar phenomenon has been investigated at Wye,[18] where field trials have demonstrated that the incorporation of vegetable oils with Bordeaux mixture improves the adherence of the Bordeaux deposit to an extent such that it is possible to reduce by one-half the concentration of copper sulphate and lime used, and yet to retain fungicidal efficiency.

When applied in combination with nicotine, which is the most widely used of the contact insecticides, petroleum oils improve activity by a somewhat different type of action. It is generally assumed that the efficiency of contact insecticides, with which a direct toxic action is more important than a protective ability, is associated with the ease with which the spray wets the insect, and it is the practice to add so-called "spreaders" such as the soaps to improve the wetting ability of nicotine washes. A similar improvement in contact insecticidal efficiency has been shown when nicotine has been added to petroleum oil washes,[13] and Austin, Jary and Martin[4] found that this action is also shown by glyceride oils. The cottonseed oil-Bordeaux emulsion was as effective a carrier of nicotine as the usual soap spray. This improved insecticidal action is probably associated with the excellent wetting properties of the oils themselves, a hypothesis which would seem to require that the insecticide be oil-soluble.

With insecticides which are not oil-soluble, for example, rotenone and derris extracts, it is possible to use types of petroleum products which function as water-soluble spreaders. The soaps, which have already been mentioned as widely employed to improve the wetting and spreading properties of sprays, suffer the grave disadvantage that the insolubility of their calcium or lead salts prevents their use with many of the more important spray materials—*e.g.*, Bordeaux mixture, lime sulphur, lead arsenate. There is therefore an urgent need for cheap soap substitutes of which the wetting properties are not affected by the addition of soluble calcium salts.

An investigation of likely sources of such soap substitutes carried out at Wye[19] naturally included the petroleum derivatives known to yield capillary-active salts—*e.g.*, the naphthenic acids and the various types of sulphonic acid and sulphated derivatives

produced in refinement processes. The naphthenic acids proved unsatisfactory, for not only are the calcium naphthenates insoluble, but the samples, submitted through the courtesy of several oil refiners, proved dangerous to use on foliage because of the presence of free oil of low unsulphonated residue. The sulphonic acid derivatives examined proved most complex, but fortunately the early difficulties of classification were prematurely solved by the publication of a system of classification by Pilat, Sereda and Szankowski,[24] which proved immediately applicable. This classification is based on the solubility relationships of the calcium sulphonates. Sulphonic acids yielding calcium salts soluble in water and insoluble in ether were termed the gamma-acids, those of which the calcium salts are insoluble in water but soluble in ether were called beta-acids, the alpha-acids being those of which the calcium salts are insoluble in both water and ether. The particular group suitable for the preparation of soap substitutes for spray purposes is therefore the gamma-sulphonates.

The gamma-sulphonates appear in the acid layer from the sulphuric acid treatment of heavy oils, and they may be extracted in crude form by simple neutralisation of the acid sludge with lime, filtration and evaporation to dryness. The brittle pitch so obtained has proved, in field trials, a successful spray spreader. A concentration of up to 2 lb. per 100 gals. of the crude calcium gamma-sulphonates imparts sufficient wetting properties for most spray purposes. The most important objection to their use is the lack of chemical methods of standardization, but the investigations of Pilat and his colleagues[22,24] provide promising indications that this objection may soon be removed.

The active constituents of the majority of the products sent me by oil refiners in connection with the search for soap substitutes proved to be the beta-sulphonates. These products were obtained generally by the alkali or alcohol treatment of the oil layer subsequent to acid refining, and were called by various names such as "naphthenic sulpho-acids," "soda acids," "soda soaps" and "sodium sulphonates." The sulphonic acids, isolated through their barium salts, gave sodium salts which functioned admirably as soap substitutes at concentrations of the order of 0·2 per cent. Further, spray trials indicated that the crude products may be used without separation of the free oil and sodium sulphate present, for this oil is generally of a high degree of refinement and safe for use as an insecticide on foliage. We have successfully employed a crude product of this type, yielding an analysis 31 per cent. by weight of high-boiling petroleum oil, 8·5 per cent. sodium sulphate and 48·2 per cent. beta-sulphonic acids, for the control of red spider on cider apples. The usefulness of the beta-sulphonates

as spray spreaders is limited by the insolubility of their calcium salts. The beta-sulphonic acids and their sodium salts appear, however, to be relatively soluble in hydrocarbon oils, and it is possible that they may prove a useful ingredient for the manufacture of the so-called miscible oils. The miscible oils, which are single-phase preparations yielding emulsions on addition to water, are a popular type of manufactured oil product employed by the grower for the preparation of oil sprays.

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[29] Swingle, H. S., and Snapp, O. I., *U.S. Dept. Agric.*, 1931, Tech. Bull. 253.

[30] Tutin, F., *J. Pom. Hort. Sci.*, 1932, **10**, 65.

DISCUSSION.

The President remarked that those members who were not qualified to criticise the results which had just been presented to them by Dr. Martin, could nevertheless appreciate the large amount of careful and detailed experimental work which formed the basis of the paper. Fortunately, there were present that evening representatives of the following important bodies : the East Malling Research Station, Kent, the Royal Botanic Gardens, Kew, the Imperial Institute, the Ministry of Agriculture and Fisheries, the Plant Pathological Laboratory, the Rothamsted Experimental Station and Imperial Chemical Industries. He extended a cordial welcome to those representatives and to all the Institution's visitors, and expressed the hope that they would give the meeting the benefit of their expert knowledge of the subject matter of the paper.

Major T. R. H. Garrett said that facts of great interest to the user of these washes were to be culled from the paper. For example, one that interested him greatly was that for the winter washes 5 per cent. was ample strength, whereas the manufacturers instructed purchasers to use 8 per cent.

He had been ill for some time, he said, and therefore did not know whether it was possible to buy an oil of the description that Dr. Martin had given as the most efficient—namely, a highly refined lubricating oil of low specific gravity, with a casein spreader. He presumed that this was a spindle oil of low boiling point. If horticulturists possessed such an oil, they could delay the washing until much later in the season, and would therefore have longer days, better weather and greater control, without the risk of damage to the moving buds. He asked Dr. Martin whether he had made any experiments on the control of the Woolly Aphis, *Eriosoma lanigerum*, with these oils. This had been, he related, his most serious pest. His friends at East Malling had furnished him with, and had installed, the parasite *Aphelinus mali*, but his strain of Woolly Aphis had been only slightly attacked and not greatly reduced in numbers. Then he had started trying petroleum washes at 8 per cent., and had obtained a reduction of the numbers on the trees washed as against the numbers on the control trees. From the habits of the pest, however, it would take three or four years to eradicate. Then, unfortunately, he had fallen ill, and could not continue with his experiments. Concerning the summer washes he knew nothing at all, as he had never used them.

Mr. C. T. Gimingham said that Dr. Martin's work was of great value. The farming and fruit-growing community had for a large number of years tended to accept its accessories in the way of spray fluids and such substances without enquiring too closely

into their composition or asking too many questions about them. In recent years, however, the horticulturists, and particularly the large fruit growers, had shown an increasing disposition to ask more about the materials which they used as insecticides and fungicides. There had been a growing and insistent demand from the fruit growers for more standardized products than they often obtained in the past for these purposes, and for some sort of guarantee that the materials bought should conform to a reasonable standard of efficiency and of safety in use, and also that they should not vary widely in composition and effect in different seasons and at different times. The grower had suffered in the past from that kind of uncertainty. Many spray fluids had only a small margin of safety—and it was, indeed, difficult to provide materials deadly to the insect and harmless to the plant. This applied more especially to products for use in the summer, but it also held good to some extent for winter washes, including the oil washes. When the subject was regarded from this point of view it was obvious that the kind of work that Dr. Martin had been doing was of great value to the grower. The grower's problem was to some extent solved if he could ask for a material which should conform to a definite composition and quality—a definite specification, in other words. If such reliable specifications could be drawn up, the position would be much more satisfactory. It was precisely the kind of work that Dr. Martin had been doing, and about which he had been talking that evening, that provided the kind of information which would make it possible to draw up such satisfactory specifications. This was why the community of growers, particularly fruit growers, welcomed this work so heartily.

It was further satisfactory, he continued, from the grower's point of view that Dr. Martin's results suggested that such a comparatively wide range of oils were suitable for use in the winter. He was sure that Dr. Martin himself would be the first to admit that there was still quite a large amount of work to be done in the direction of the correlation of the chemical and physical properties of oils and other materials on the one hand, with biological activities on the other. Nevertheless, a substantial start had at last been made, and technologists were already in a much better position than they had been a short time ago to advise the grower on the type of oil which he should buy for any particular purpose and for the control of any particular pest. He did not profess himself to be competent to discuss the technical details of Dr. Martin's paper, and he had not come to the meeting to talk. He hoped to hear something of the views of the people who were directly concerned with the production and technology of the oils themselves, and to ascertain whether the matter was really of interest to them.

Mr. L. Stenning feared that he had not had the same experience that Dr. Martin had of field work with oil on fruit trees. The trees of which he was in charge would not tolerate the use of oil to the extent that Dr. Martin used it. Many tropical plants would not stand up to the oils which Dr. Martin had mentioned, because of the tenderness of their foliage. He desired to hear from Dr. Martin whether he knew if such oils could be used on trees such as avocado pears, coffee, tea and citrus—especially the last. This information would interest him particularly, as he knew for a fact that in a good many parts of the world orchards became infested with scale, and to his knowledge the only preparation that would touch it was one of the oil insecticides.

Dr. F. H. Garner referred to Table I. of the paper, in which the conclusion was drawn that all the oils tested had been quite satisfactory with the exception of P–5, which was an oil of high viscosity ; variations of viscosity, boiling range, or unsulphonated residue were not accompanied by any definite alteration in ovicidal action.

In reference to the statement made in the paper that the action of the summer wash was due to " stifling " action rather than to chemical toxicity, he asked the author whether he was of the opinion that the petroleum oil by itself had practically no toxicity at all. He also asked Dr. Martin to amplify his remarks as regards the method of production of the gamma sulphonates, since apparently certain acid tars consisted largely of beta sulphonic acids rather than gamma sulphonic acids.

Mr. H. J. Holman admitted that up to the present he had always found information on the action of oil washes extremely vague. In spite of all the research work that had been done on them, the position had always been obscure, and only that evening, when he had heard the paper, had he understood something of the actual position. Dr. Martin had mentioned injury to foliage. He had possibly read a paper that had been published by Morris and Young in the United States. These authors had done some work on the summer washes with 25 different types of oils on over 2000 apple limbs. Their experiments had taken place over seven years, and therefore should be fairly comprehensive. They had found that oils to be used on foliage should not be more than 15 per cent. sulphonatable, and preferably not more than 5–10 per cent. For buds, they suggested that it could have up to 45 per cent., which was not a very refined oil. He asked whether Dr. Martin had had any experience of oils of that type, and whether he considered that oils with such a high percentage of sulphonatable material could be used.

Another point, he remarked, had not been mentioned : this was the question of the effect of these washes in forcing the foliage and bloom. In South Africa some work had been done by Dr. Mally, in which fruit trees had been sprayed with various oils, including mineral oils in order to improve the regularity of blossoming. Mineral oils were found to force the foliage and bloom. He asked whether Dr. Martin had had any information concerning this action in this country.

Mr. C. Chilvers said that, assuming the emulsions in question were of the oil-in-water type, it would be expected that the insects or eggs would be preferentially wetted by water. If this is the case, it is rather difficult to understand how the film of oil, which exerts the stifling action referred to in the paper, is formed, as this suggests that the insects, etc., are preferentially wetted by oil. Perhaps the author can give some information on this point.

Dr. S. Pilat, in a written communication, said that Dr. H. Martin's comments with reference to the utilisation of sulphonic acids should be of a particular interest to every refiner engaged in the production of lubricants. As the average acid sludge contains at least about 30 per cent. of sulphonic acids, and as the major part of lubricants is still obtained by treatment of oils with sulphuric acid, it is apparent that the quantities of sulphonic acids which can be easily produced from waste acid are of undoubted commercial importance.

In connection with Dr. Martin's outstanding work, he would mention that it had been discovered some years ago that alpha sodium sulphonates are of a remarkable toxicity to wood parasites. This was fully confirmed by a number of successful laboratory tests with *Coniophora cerebella*, *Polyporus vaporiarius* and *Merulius lacrimans*, and thereafter by practical application on wooden constructions infested by such parasites.

It has been found later by his collaborator, Mr. Sereda, that some of the ammonium sulphonates can be adequately used in place of ichthyol preparations. A product of this type is manufactured and marketed in Poland under the denomination of " naphtamon."

In order to investigate the bactericidal properties of other sulphonates, attempts were made to prepare a silver salt soluble in water. As most of the silver sulphonates do not yield aqueous solutions, products of a further sulphonation of the alpha salts, which can be thus converted into water-soluble calcium sulphonates, were investigated to that effect. His collaborator, E. Neyman, succeeded finally in obtaining a silver sulphonate readily soluble in water with 30 per cent. silver content. The therapeutical

result of this silver salt, which is manufactured and sold as "naphtargol," has been ascertained by numerous clinical reports as being of a particularly strong bactericidal action on *bact. coli*, *diplococcus Neisseri* and *bact. Ducrey*.

There is still one point, although of minor importance, to which he wished to call the author's attention. Calcium sulphonates of the gamma series are insoluble in ether, and the systematic classification of the sulphonic acids resulting from the treatment of mineral oils with concentrated (not fuming) sulphuric acid runs as follows :—

Sulphonic Acid.	*Source.*	*Solubility of Ca Salts. In Water.*	*In Ether.*
Alpha ..	Recovered from acid sludge ..	Insoluble ..	Insoluble
Beta ..	Recovered from alkali sludge ..	Insoluble ..	Soluble
Gamma ..	Recovered from acid sludge ..	Soluble ..	Insoluble

Mr. G. R. Nixon, in a written communication, said that the method of distillation used in evaluating the lubricating oils may be regarded as unsatisfactory. A better method would have been to carry out the distillation test at 25 mm. or 10 mm. pressure and record the percentage of distillate at 200° C., 225° C., 250° C. and so on. Heavy gas and fuel oils, if ever examined as spray materials, could also be evaluated in this way.

The test for the determination of unsulphonated residue is one that is unlikely to be used in the petroleum industry, since it would be difficult to standardize and the interpretation of the results would be complicated. If such a test is necessary—*i.e.*, some test for stability—he suggested the aniline point test should be examined ; thus the higher the aniline point the better the oil.

With regard to the ovicidal activity of petroleum products, it would be of interest to know whether the author has tried the effect of aqueous emulsions of low melting point paraffin waxes or of aqueous emulsions of lubricating oils containing in solution a proportion of low melting point paraffin wax—*e.g.*, match wax of M.P. 110° F. At first sight it would appear that such emulsions would give a better continuous film over the eggs than an emulsion of oil alone.

The use of mineral oil sulphonic acids as activators of contact insecticides has been demonstrated by Petrov, Isachenko and Goritzkaya, and is in agreement with the author's results.

Dr. Martin, in reply, said that Major Garrett had considered that his results indicated that proprietary washes could be used at 5 per cent. dilution, whereas the makers recommended use at 8 per cent. This was not so. The concentrations recorded were of actual oil content whereas the manufactured product

was possibly 2/3, perhaps 4/5, oil. Further, in laboratory tests and small scale trials, the experimenters were able to give individual attention to each twig sprayed or dipped, and were sure of getting each wash where they wanted it. In the field they were not quite so certain, and had to employ higher concentrations in order to achieve the results which they obtained in the laboratory.

Major Garrett's second point, said Dr. Martin, concerned the commercial availability of the low boiling point spindle oils of the type suggested for use as summer washes. He could only say that he himself had met no difficulty, perhaps as a privileged person, in obtaining an adequate supply of oils. With regard to the date of application, Major Garrett had wished to have the spray programme modified, so that all spraying could be postponed until the longer days, the better weather, and so on. In practice the date of application was governed entirely by entomological considerations. It was quite evident—to give one instance—that the Aphis, once it had curled up the apple leaves, was more or less protected from sprays. No spray had yet been produced of wetting and spreading ability such that it could penetrate inside the tightly curled leaf. The wash had to be applied when the insect was in its most vulnerable state.

Major Garrett suggested that Dr. Martin had misunderstood him. He had not, he said, referred at all to the summer washes, of which he knew nothing, but had been talking exclusively of winter washes.

Dr. Martin admitted that with the winter washes the date of application was less definitely controlled by entomological considerations. With the tar oils, he said, it did not seem to matter, so far as the control of Aphis and sucker was concerned, at what time during the dormant season the sprays were applied once the eggs are laid. The eggs were apparently killed very soon after the spray application and the date of application was therefore relatively unimportant. With the petroleum oils, which exerted not a chemical toxic action but a physical stifling action upon the developing embryo, the nearer the date of application approached the date of hatching of the insect egg the greater the certainty of ovicidal action. There was enough practical evidence available to enable him to make the definite statement that, with the stifling action, if the oil were applied late, the results were better.

Of the action of petroleum oils on Woolly Aphis, the speaker was unfamiliar, but the following point might be made. In the summer, there was an enormous dense mass of Aphis piled one on top of the other, covered with the wool ; if they were attacked in

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the summer by chemical methods, and not by the biological method mentioned by Major Garrett, no spray known could hit the top of the mass and penetrate through to the Aphis underneath. If, however, the pest were attacked in the winter, the chances of destroying it were greater, because it was not reproducing vigorously and there might only be one or two members in the colony to kill.

Mr. Stenning had asked about the application of petroleum oils as foliage washes for plants such as avocado pear, coffee and citrus. Dr. Martin regretted that he could say nothing whatever about the pear, but he would imagine that coffee would stand practically anything. If he remembered aright, coffee had a thick-leaved tough foliage, and, in Trinidad, the planters attempted to defoliate coffee for some specific purpose—he thought fungus disease. They had, therefore, applied crude petroleum oils, but to their astonishment they failed to defoliate the tree. It was mainly on the citrus and against citrus scales that practical American work had been carried out with petroleum oils. It had been found necessary in America to specify five grades of petroleum oils, all of which were highly refined but varied in viscosity, for specific purposes.

Dr. Garner, he continued, had enquired about chemical composition and the toxicity of petroleum oils. As regards winter washes, the types of oils had been described in Table I. Dr. Martin wondered whether there was any large fluctuation in chemical composition between petroleum oils of the types illustrated in that table. His own impression was that although they contained hydrocarbons of different boiling points and different molecular weight, the chemical properties varied quite evenly with the different groups of paraffinic and naphthenic unsaturates and aromatics. It seemed rather questionable whether there could be any great fundamental differences in the chemical types of compounds present.

The conclusion that the petroleum had no real toxicity but exerted its effect purely through its physical action, by making an impenetrable film of oil, was, continued Dr. Martin, the conclusion from the data available. In the case of tar oils, however, it would appear that some group of compounds present, possibly the aromatic hydrocarbons, possessed definite chemical toxicity. The winter moth, capsid and red spider in particular were less sensitive to this toxic action than Aphis and sucker eggs.

Dr. Garner, he said, had asked for information concerning the separation of the sulphonic acids. The gamma sulphonates were found in the acid tar—in the acid phase; the beta sulphonates existed mainly in the oil phase. To separate the gamma sulphonates

he had followed Pilat's procedure, which consisted of the neutralisation of acid tar with lime, followed by filtration and evaporation to dryness. The beta sulphonates which he had recovered himself had all been from the oil phase, after sulphonation. He had sulphonated the oil under fairly drastic conditions, and had withdrawn the supernatant oil and extracted the beta sulphonates from it. The lower acid layer had been the source of the gamma sulphonates.

Mr. Holman had quoted the experiments of Morris and Young, who had endeavoured to find out the cause of the acute toxicity of petroleum oils to foliage—the actual burning of the leaves and destruction of leaf tissue. For application to foliage these authors had recommended that the petroleum oils should contain not more than 15 per cent. sulphonated residue. He was almost certain that 15 per cent. sulphonated residue referred to the part of the oil which was sulphonated, and that the use of the word "residue" in that connection was erroneous. The residue remaining after sulphonation was the unsulphonated part, and this would presumably be 85 per cent. These authors, however, preferred an oil of which only 95 to 90 per cent. was unsulphonated, their exact expression being 5–10 per cent. sulphonated. For use at the delayed dormant stage, they suggested 45 per cent. sulphonated residue, which he took to mean 55 per cent. unsulphonated residue. This figure was in close agreement with the 60 per cent. which he and his colleagues had found to be a suitable minimum.

Referring to the remark that the workers in South Africa had found that the application of petroleum oils forced the bloom, he said that it would be extremely interesting to know the precise details of that observation, for his own experience had been in the other direction. In cases where the Wye workers had used petroleum oils in the field against apple capsid, they had been obliged to use a certain amount (up to 4 per cent.) of tar oils, in order to control Aphis and sucker, in addition to 6 per cent. of petroleum oils, giving a wash of 10 per cent. total oil concentration. Under most conditions in most orchards a wash of this concentration killed the buds. When oil concentration was reduced, they found not a forcing of the blossom and foliage buds, but a retardation. This effect on the apples had been so marked that the workers had been obliged to reduce oil concentration to a point below that at which they obtained effective control of capsid.

Further speakers had referred to the damage caused by the naphthenic acids. He had given examples of two naphthenic acid preparations which had been submitted by oil refiners while

he had been at Wye ; his analysis of the first of these products had shown it to contain 32·8 per cent. of neutral petroleum oils and only 63·6 per cent. of naphthenic acids. The neutral oils which he had isolated had had an unsulphonated residue of 51 per cent. by volume, a degree of refinement greatly below 90 per cent. which he had given as the minimum figure for foliage sprays. In spray trials the naphthenic acid neutralised with sodium hydroxide was applied to hops and at 1 per cent. concentration had caused fatal injury to the leaves. The second sample had given an analysis of 10·6 per cent. of neutral oil—somewhat less —but unfortunately the unsulphonated residue of that isolated oil had only been 13·7 per cent. These two examples would show that the naphthenic acids as submitted by the refiners had not been safe materials for recommendation. Obviously, if the crude oil were removed, the cost of the material would be increased, an economic point beyond the scope of the paper. But even when refined naphthenic acids were used at 0·64 per cent., neutralised with sodium hydroxide, spotting injury of the hop leaf was caused, and it appeared that the sodium naphthenates themselves might be toxic at low concentrations.

The subject of preferential wetting by oil emulsions was one of extreme difficulty. It was not even possible to measure adequately in the laboratory the wetting properties of ordinary water-soluble materials, such as the beta sulphonates, and the only method had been to take the material into the field, and try it on specific plant surfaces or insects. In considering wetting by an oil-in-water emulsion, there were two factors, the oil and the aqueous phase, and the complexity of the laboratory investigation became more than doubled. The matter was one of great practical importance because, with the quick-breaking, highly refined petroleum oil sprays, the spray collects in droplets on the sprayed surface. The grower, seeing this effect and considering it an indication that the spray was unable to wet, became dissatisfied. There was therefore a tendency, especially on the part of manufacturers, to incorporate water-soluble spreaders in oil washes. Dr. Martin doubted whether they were acting on the right lines, for this collection of the spray into droplets was one indication of the fact that it was the oil and not the water, the aqueous phase, that functioned as the spreader. A second indication that with these quick-breaking materials there was a preferential wetting by the oil was the evidence of insecticide tests. The oil-Bordeaux-nicotine spray contained no water-soluble spreader, yet the spray was as effective as the soap-nicotine spray. It is probable that this efficiency is associated with the ability of the oil to act as a spreader.

Dr. Pilat, who had been so good as to send a written communication, had been extremely helpful to Dr. Martin in the work, and had done an enormous amount of investigation on the sulphonic acid derivatives. It would interest members to know that not only was Dr. Pilat obtaining information on the molecular structure of the sulphonic acids, but he was able to convert alpha acids to gamma acids by simple processes.

The possibility of utilising the heavy metal salts of the sulphonates as fungicides, insecticides and bactericides was a problem of which only the bare fringe had been touched. It was somewhat staggering to have to admit that investigators did not yet know the why's and wherefore's of the fungicidal activity of a widely-used copper fungicide like Bordeaux mixture. When, therefore, they came to consider the fungicidal activity of copper naphthenates or sulphonates, they were even more in the dark.

In reply to Mr. Nixon's comments, Dr. Martin admitted that the methods suggested for the determination of boiling range and of unsulphonated residue were not of a high standard of analytical excellence. They do, however, provide information of great value in evaluating the biological properties of petroleum oils, for which purpose absolute figures of definite chemical meaning do not appear to be necessary.

With reference to the employment of paraffin wax in petroleum oil emulsions, Dr. Martin replied that preliminary tests had been carried out at Wye upon the effect of incorporating petroleum jelly in the wash, but as no noteworthy improvement in ovicidal efficiency was observed, these tests were discontinued because of the pressure of work on other lines. A proprietary product containing a petroleum oil solution of a saponifiable wax was also used, but it showed no superiority over petroleum oil washes and the product did not appear on the market.

The President remarked that all members would agree that Dr. Martin had replied very fully and thoroughly to all the points that had been raised in the discussion, and would wish to signify in the usual way their appreciation of his paper.

A vote of thanks was carried with acclamation.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.

TRINIDAD BRANCH.

THE SIXTH ANNUAL GENERAL MEETING of the Institution of Petroleum Technologists (Trinidad Branch) was held at the Apex Club, Fyzabad, on Wednesday, November 29th, 1933, Mr. G. H. SCOTT, B.Sc., Chairman, occupying the Chair.

The following paper was presented by the Author :—

Some Malarial Problems in Trinidad and Their Control.

By ERIC DE VERTEUIL, M.D., B.S. (Lond.), D.P.H. (Lond.).

The study of malariology in Trinidad—as elsewhere—is really confined to three main factors :—

1. To the study of malaria, *i.e.*, the amount of malaria—the relative proportions of the various types of malaria—the incidence, mortality, and so on.
2. To the study of the transmitter of malaria, *i.e.*, the Anopheles mosquito.
3. To the control of malaria, which is really the outcome of the study of the first two factors.

HISTORY OF MALARIA WITH SPECIAL REFERENCE TO TRINIDAD.

Malaria is as old as the hills and even as far back as the days of Hippocrates, and, indeed, several centuries B.C.

Quotidian, tertian and quartan malaria were well recognised and accurately described, and were known to occur especially in the vicinity of swamps and stagnant water. But from this period on malaria passed on down the centuries without any noteworthy discovery concerning its nature, its cause, or its control, until it was left to Laveran, a French Army surgeon, to discover, in 1880, the malaria parasite in the blood of persons suffering from malaria. Subsequently Ronald Ross showed that the parasite was transmitted from man to man through the agency of the Anopheles mosquito.

In Trinidad, as far back as 1900, Mr. F. W. Urich was working at the various species of Anopheles present in Trinidad, and in 1902 Dr. C. F. Lassalle took over some specimens of Anopheles to England for identification.

Panama was the next scene laid by Gorgas to show to the world that it was possible to control malaria by anti-larval methods, *i.e.*, by destroying the larval or aquatic forms of the Anopheles mosquito, principally by means of drainage, filling and oiling.

Again Trinidad was one of the foremost countries to apply that knowledge to local conditions. Within a few years Dr. Dickson

had made very marked progress in stamping out malaria in Port-of-Spain, and subsequently Dr. Lassalle and himself extended their activities to the rural districts all over the island with very marked success.

Meanwhile, between 1918 and 1929, anti-larval work, with proper screening of bungalows, was carried out on a large scale and with excellent results *pari passu* with the rapid development of the petroleum industry in the south.

Such well-known malarious centres as Brighton, La Brea, Pointe-à-Pierre, Fyzabad, Apex, Point Fortin and Guapo gradually but surely yielded to continuous scientific anti-malarial efforts which—to their credit be it said—were so freely encouraged by the management of these various oilfields.

At first it was thought that Gorgas anti-larval methods could be universally applied with success, but soon it was discovered that this was not so, and, in fact, that malarious conditions varied enormously in various countries and even in various localities of the different countries, and that, therefore, each country had to study and work out its own problems, its own salvation and its own method of control.

Malaria Surveys.

Malaria surveys began to be generally considered, and a very large number of these surveys has since been made in various parts of the world.

Ross and Malcolm Watson were at first prominent in this kind of work in the East, and in Panama Dr. Darling carried out a really remarkable set of experiments which established the facts clearly, not only that the Anopheles was the only kind of mosquito capable of carrying malaria, but that only certain species of the Anopheles were malaria carriers.

The method of control by eliminating the particular species is known as "species control" or "species sanitation," and now appears to be the direct result of most malarial surveys in the various parts of the world, Trinidad included.

The present malaria survey began in Trinidad in September, 1930. At that time, thanks mainly to the work of Mr. F. W. Urich, Dr. Dickson and Dr. Lassalle, the existence in Trinidad of thirteen species of Anopheles was known, only three of which appeared to be of any importance from the malaria point of view.

Breeding Places.—The breeding places of these different Anopheles, as well as the malarious centres in different parts of the island, were known; and, furthermore, in a large number of instances the breeding places could be accurately correlated with the malarious centres.

It has also been learnt from experience that Gorgas' anti-larval methods of controlling malaria in Panama (*i.e.*, by eliminating the breeding places of the Anopheles by filling, draining and oiling) were a practicable measure in Trinidad.

It is clear, therefore, that a greater part of the work in connection with Anopheles identification and distribution, and with regard to the localisation and the method of control of the centres of malaria in various parts of the island, had already been carefully considered and planned.

It was now left to the Malaria Survey Department to :—

(*a*) Fill in the gaps in connection with the identification and distribution of the Anopheles ;

(*b*) Study closely and ascertain accurately the malaria-carrying powers and the habits of the various species of Anopheles ;

(*c*) Make intensive spleen and parasite surveys in connection with the ascertainment of the kind and the quality of malaria present in the areas under survey ; and, finally,

(*d*) To apply such knowledge in the control (and in some areas possibly in the eradication) of malaria in a more scientific and comprehensive manner than was hitherto possible.

A malaria survey actually includes four distinct methods of survey :—

1. A spleen survey. } These are usually carried out at the
2. A parasite survey. } same time on the same persons.
3. A topographical survey.
4. An Anopheles survey.

1. *A Spleen Survey.*—Shortly is an examination of *samples* of the population in various parts of the country for enlargement of the spleen, the result being expressed as a percentage of enlarged spleens found amongst the number of persons examined.

For obvious reason, school children (between the ages of 4 and 12) attending school are usually chosen as samples. The actual examination is easy and accurate ; the assistance of the teachers is available ; and it is an excellent opportunity for having a short talk on malaria ; and, in addition to these advantages, a child's spleen is particularly sensitive to enlargement when it is infected with malaria.

Enlargement of the spleen may, of course, also be caused by other conditions, *e.g.*, infective diseases, blood diseases, and so on, and, as a matter of fact, we usually allow for this in considering the spleen rates in various countries.

For instance, a spleen rate in Trinidad of, say, 2 to 6 per cent. (*i.e.*, enlargement of the spleen in 2 to 6 children out of every

100 examined) would be considered as more or less negligible, and would certainly not form a malaria or public health problem.

Ten per cent. would be a low spleen rate.

Twenty-five per cent. would be high.

Fifty per cent. would be very high.

Over 50 per cent. would be expected in hyperendemic areas where malaria had existed over a large number of years on a large scale, *e.g.*, a village near a mangrove swamp.

The spleen rate of children (from 4 to 12) attending school in 1930–31 at Success Village was 51 per cent. ; at Chaguaramas Village, 82 per cent. ; at Teteron Bay, 48 per cent. ; at Freeman's Road, 40 per cent. ; at Tunapuna Village, 5 per cent.

The enlargement of the spleen which malaria causes in children as well as in adults often persists for months, and sometimes for years, and on that account it is customary to express the enlargement of the spleen as follows :—

Spleen not enlarged	0
Spleen just palpable on deep inspiration	P
Spleen enlarged to 1 finger breadth below costal margin ..	I
Spleen enlarged to 2 fingers breadth below costal margin ..	II
Spleen enlarged to 3 fingers breadth below costal margin ..	III
Spleen enlarged below the umbilicus	B.U.

2. *A Parasite Survey.*—Is usually made at the same time as the spleen survey, on the same samples.

It consists in an examination of *samples* of the population for the presence of malaria parasites in the circulating blood.

The result is usually expressed as a percentage of positive bloods found amongst the number of persons examined. This is called the *parasite index.*

At the same time of the examination of the blood, the kind of parasites present are also noted and expressed as a percentage, *i.e.*, whether the type of malaria present is benign tertian, quartan or malignant tertian.

Obviously, the parasite index would be much higher in the malaria season than in the off season.

The parasite index of children (from 4 to 12) attending school at Success Village was 13 per cent. ; at Chaguaramas, 13 per cent. ; at Teteron Bay, 2 per cent. ; at Freeman's Road, 17 per cent. ; at Tunapuna Village, 3 per cent.

Obviously, the parasite index by itself is a most useful indication of the intensity of malaria and of the type of malaria.

But in actual practice it is always considered in connection with the spleen rate, as the two together form a most reliable and

accurate estimate of the intensity, the type and the distribution of malaria.

3. *A Topographical Survey.*—It is obvious that a thorough knowledge of practically every square yard of the survey area is necessary before the question of control can be efficiently considered. The engineering aspect must also be considered, and a closer co-operation between the engineer and the sanitarian would be most welcome.

The next and last survey which goes to form a malaria survey is :

4. *An Anopheles Survey.*—It consists essentially (1) in making a collection of the larvæ and pupæ of the various species of Anopheles in their various breeding places, breeding them out in the laboratory and identifying the adults which hatch out ; (2) in searching special spot houses, pig-sties, stables, etc. (usually near extensive breeding places), for the prevalence of adult Anopheles ; (3) making a special study of the nature of the breeding places of the Anopheles, *e.g.*, whether the water is stagnant or running, clear or muddy, shady or sunny, sweet or brackish, or foul and so on.

Since the beginning of the survey only four species of Anopheles have been commonly met with, and as a result of these surveys in various areas in Trinidad and in Tobago the breeding places, the habits and the general life history of these four species are now well known.

Species Sanitation or Species Control.

But before considering such methods of control, it will be of interest to give you a short description of the general life history of these four Anopheles.

Tarsimaculatus.—Tarsimaculatus is by far the commonest Anopheles, and is, unfortunately, also the principal and most dangerous malaria carrier in Trinidad. It is essentially a brackish water breeder and finds a permanent home in stagnant mangrove swamps and stagnant coconut drains along the sea coast.

From June to September, however, during the heavy rains of the rainy season the breeding becomes very intensive, especially after a prolonged dry season (such as in 1931), and this is followed by migration in large numbers into inland areas for distances up to 2 or 3 miles.

During 1932 the tarsimaculatus problem was closely investigated at Chacachacare Island, where three mangrove swamps were found to be breeding Anopheles tarsimaculatus on a big scale.

These swamps have since been partly or wholly filled and were regularly flooded with sea water so that all breeding had been definitely eliminated, and yet subsequently tarsimaculatus adults were captured on the Island on several occasions.

The nearest breeding place in Trinidad is Teteron Bay and Scotland Bay about 5 miles away, whilst the Venezuelan coast is about 8 miles away.

One cannot help suspecting that some tarsimaculatus adults were being wafted in from Venezuela.

When dealing with brackish water breeding places, *samples* have usually been taken and sent to the Government analyst to find out the percentage of sea water present.

Equatorial sea water is considered to be 100 per cent. and to contain 1·94 per cent. chlorine. About 200 odd samples have already been sent for analysis, including numerous samples of sea water taken in many places along the coast; and at Chacachacare, and some interesting and instructive results have been obtained.

For instance, during the dry season the gulf water at the end of St. Vincent Jetty in April, 1931, was about 100 per cent. equatorial sea water, whilst in the rainy season in July and August, 1933, it was found to be as low as 70·9 per cent. in La Tinta Bay, Chacachacare, and 58·5 per cent. in October off Monkey Point, Couva.

Under such circumstances, it is quite clear that brackish water in our mangrove swamps (the home of the tarsimaculatus) varies in salinity at various times of the year from 100 per cent. in some places to perhaps 1 per cent. or less in heavy rainy periods in other places.

It was obviously necessary, therefore, to establish clearly the range and salinity through which the tarsimaculatus is able to breed in brackish water.

Again, when tarsimaculatus adults are made to lay their eggs in brackish water with a salinity between 1 per cent. and about 70 per cent. of equatorial sea water, these eggs will turn into larvæ, the larvæ into pupæ, and the pupæ into adults. But if the salinity be increased to, say, 80 per cent. of equatorial sea water, then the full development will not take place—*i.e.*, the eggs will hatch out into small larvæ which, however, live for only one or two days and then die.

The most intensive breeding has been found in stagnant brackish waters with a salinity between 20 and 45 per cent. of equatorial sea water. It has also been proved conclusively that where the brackish water of the swamp is definitely tidal—*i.e.*, where there is a marked rise and fall with a flushing movement of the waters of the swamps—then no breeding takes place even where the swamp water has a salinity which is favourable to breeding—*i.e.*, anything between 1 and 70 per cent. *equatorial sea water.*

Albitarsis.—This anopheles is one of the principal malaria carriers in Brazil; it will probably prove to be our principal carrier in the districts away from the seacoast where the tarsimaculatus does not exist.

The larvæ are found only in sheets of clear fresh water well exposed to sunlight and having a soft muddy bottom. Such places as young rice fields, ponds, large coal pits, and large open stagnant water courses form her favourite egg-laying resorts.

The larvæ are especially shy and elusive and are fond of diving down into the soft mud below on the slightest movement of the surface of the water, and in that way often escape the attentions of a sanitary inspector.

The adults are definitely house haunters, but have been usually found in small numbers as compared to tarsimaculatus.

Oswaldoi.—This Anopheles breeds only in fresh water in inland areas away from the sea-coast and is particularly interesting for many reasons.

Up to about two years ago it was considered to be tarsimaculatus; but as it became gradually established that tarsimaculatus was essentially a brackish water breeder, specimens caught at Arima were sent to Panama and to England to be identified.

They were there clearly identified as Oswaldoi.

As soon as the very small taxonomic difference between tarsimaculatus and Oswaldoi was recognised, a short study of its habits showed that its favourite breeding places were grass-grown ravines and drains and stagnant pools, where they bred in very large numbers in inland areas away from the sea-coast, such as at Arouca, D'Abadie and Arima.

They were also found to breed in ponds and coal pits, and to be nothing like so particular in their breeding habits as is *Albitarsis*.

In spite, however, of the very large numbers of larvæ found breeding in ravines and drains quite close to the houses, there was little or no malaria, and on close investigation it was found that this Anopheles did not enter houses and apparently did not bite human beings.

It is probable that it feeds only on cows, donkeys, horses and possibly fowls. This is now being investigated.

Dr. Curry, Assistant Chief Health Officer of Panama, to whom the author is especially indebted, and who has had about 20 years of experience there, and had made a special study of the Panamanian species, has had a similar experience with Oswaldoi in Panama.

In this connection it is interesting to mention that Trinidad Anopheles are very similar to the Panamanian species, which have been closely studied for a number of years.

Neomaculipalpus (Curry) is the last of the four Anopheles commonly found in Trinidad. It was previously erroneously locally called Maculipes or Apicimacula.

Again, this Anopheles has very distinctive and definite breeding places, being found only in the muddy hoof-marks of animals, the dirty wheel ruts of estate traces, muddy pools and rivers, and the muddy rice fields soon after planting has begun.

The adult has also been caught in houses but usually in small numbers.

It has not so far been incriminated directly as a malaria carrier.

Control of Malaria in Trinidad.

The control of malaria in Trinidad must obviously be in the nature of *Species Control* or *Species Sanitation*.

Oswaldoi can therefore be eliminated as being commonly a non-biter of human beings and therefore a non-carrier of malaria.

Neomaculipalpus, a doubtful malaria carrier, can also be rapidly dealt with owing to its distinctive habits of breeding only in muddy water. So that all hoof marks, wheel ruts and muddy stagnant pools would require special attention, and be filled or drained and be prevented from recurring according to circumstances.

There remains, therefore, to consider the control of malaria caused by Albitarsis, and above all by Tarsimaculatus.

With regard to the control of Albitarsis, it has already been pointed out that it breeds principally along the grassy edges of ponds and in open sunny rice plots.

Now it has been found that where the edges of the pond are kept clear and free from grass and weeds Albitarsis disappears; so that if this condition could be permanently assured by means of emulsion or by the liquid asphalt method, as was done at Brighton some years ago, it should be possible to stop Albitarsis breeding as well as the breeding of all other mosquitoes by this method.

The control of Albitarsis breeding in the rice fields, however, is a difficult economic problem which needs more consideration than it has yet been able to receive.

It seems likely that irrigation methods with alternate flooding and drying will prove to be the solution where this is practicable.

There remains now only the Control of Malaria caused by the swamp breeder "Tarsimaculatus."

Other Methods of Malaria Control.

So far only the anti-larval method of malaria control—*i.e.*, the method of preventing permanently the breeding of certain malaria-carrying Anopheles—has been dealt with.

There are, of course, many more methods which are in use which deserve mention.

These are: 1. The mosquito net. 2. Screening of bungalows, in which connection attention must be called to:—

(*a*) The necessity for maintaining the screening in perfect condition without holes or openings of any kind.

(*b*) The use of insecticides to kill any Anopheles that may have chanced to enter inside the bungalow (as they commonly do when there are large numbers flying about).

(*c*) The real necessity for electric fans in all screened bungalows, at any rate in the sitting room and galleries.

3. The important permanent anti-malarial measure, viz., the anti-gametocyte treatment by means of Atabrine and Plasmochin or Plasmoquine Compound—*i.e.*, that when Atabrine or Plasmoquine or in some cases both are used with or without quinine, in the ordinary treatment of malarial cases the forms of the malaria parasite which are capable of infecting the Anopheles are all destroyed.

It is obvious, therefore, that the general use of Atabrine and Plasmoquine, especially in the treatment of the native children, will be of the greatest assistance in preventing the spread of malaria.

4. Yet another permanent method of malaria control which has recently been advocated is the keeping of animals in stables near the houses where screening is not practicable—*e.g.*, near barracks, cottages, etc.—the object being that the animals would serve as big bait for the Anopheles, and in that way the human beings would escape the attentions of these insects.

This method has not yet been investigated here, but it appears that it would act like a double edged sword.

The more easily blood is provided for the Anopheles by the inclusion of animals, the more intensive will be the breeding of Anopheles in that area, and the more readily will infection take place.

5. Oiling, or the use of Paris Green, or Smoking of the houses after nightfall, are merely temporary measures and should be used only when permanent measures fail or require backing up.

This list completes the usual measures of malaria control in developed areas, but one should consider shortly the essential measures which should be kept in mind in developing a new area.

There are three, in order of importance as follows:—

1. A preliminary malaria survey by a competent person. This is just as important as a survey for a water supply. The results of the survey should be considered from a broad point of view, though the details should not be lost sight of. In this connection it should not be forgotten that the degree of Anophelism—*i.e.*, the number of Anopheles—is of far less importance than the prevalence of some malaria-carrying species.

2. Careful investigations as *to the proximity and nature* of the breeding places in relation to the bungalows and barracks areas.

Remember that a screened bungalow on the edge of an extensive

mangrove swamp is as useful in keeping away Anopheles and malaria as would be, for instance, a whole array of guns (without men) in keeping away a hungry tiger from a bleating lamb. Neither measure is effective under such conditions.

This was actually tried out on the Guayaguayare beach very many years ago with disastrous results.

It must be remembered, also, that distance has a very definite effect on the incidence of malaria. The nearer the breeding places the greater the number of Anopheles and therefore the greater the amount of malaria.

3. The location of the *bungalows area at least quarter mile away* (and preferably more) from the native area.

It has long been recognised that the native population, and especially the native children, harbour a large number of malaria parasites which are capable of infecting the Anopheles, while at the same time they show few symptoms of malaria such as fever, ague, and so on, with the result that they remain untreated and are the main reservoirs of the bacillus.

It is therefore obviously just as important to keep this reservoir away as it is to keep the Anopheles away.

For the past nine or ten years a number of malaria laboratories have been attached to mental hospitals in England, and on the Continent, as well as in the United States of America.

Some of the patients in these asylums suffer from what is known as general paralysis of the insane, a disease caused by syphilis in the Tertiary stage.

It is well known that this disease, which was previously always fatal, can now be cured by injecting the patient with malaria parasites and allowing him to have about ten attacks of ague without any drug treatment—after which he is treated and cured of his malaria in the usual way.

The infection of the patient with the malaria parasites is usually entrusted to a large number of infected European Anopheles mosquitoes, often 60 to 100 at a time, and it rarely fails.

Now it occurred to the writer that by sending Trinidad Anopheles to the malaria laboratory at " Horton Mental Hospital " in Surrey, of which Col. S. P. James, of the Ministry of Health, is in charge, it would be possible to have local Anopheles tested as malaria carriers and so have a comparison with the European species.

This has actually been done for the past two years, and it is still going on. Several thousands of Anopheles of the four common species already mentioned have been bred in the laboratory and have been sent to Horton at various times.

These experiments with the Anopheles will be continued. Up to date Tarsimaculatus is the only one which has been definitely incriminated in this way.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.

TRINIDAD BRANCH

THE THIRTY-SIXTH GENERAL MEETING of the Trinidad Branch of the Institution of Petroleum Technologists was held at the Apex Club, Fyzabad, on Wednesday, January 31st, 1934, Mr. G. Hugh Scott, B.Sc., Branch Chairman, in the Chair.

The following paper was read :—

The Relation of Sub-Surface Factors to Well-Head Control in Its Influence on Rate of Flow.

By K. W. G. PATTERSON, B.Sc. (Associate Member).

The rate of flow of oil from a well at the surface is the final result of a combination of factors, each of which exerts an influence tending either to increase or decrease the rate of flow.

Their relative values may be totally different in different fields; may vary considerably from one area to another and even from one well to another in the same area.

The values of these factors cannot be computed mathematically for the reason that too many theoretical assumptions are necessary; their qualitative values will only therefore be considered.

They are given broad definitions and represented by symbols which are grouped into a formula indicating simply that an increase in the values of the factors above the line tends to increase the rate of flow, and that any increase in the values of the factors below the line tends to decrease the rate of flow.

The formula is given as follows :—

$$Q \propto \frac{ATS}{H} \times \frac{P_o}{(P_1+P_2)\ I\ (V_1+V_2)}$$

where Q = Rate of flow of oil at the surface.

A = Area per unit length of the perforations open to the producing sand. Within the limits required for the strength of the pipe and the screening effect desired the restriction to the flow of oil is decreased as this area is increased. The maximum value of A is fixed in the design of the perforated pipe, but will only preserve this value if the well remains in good mechanical condition.

T = Thickness of the producing sand from which oil has an unrestricted passage through the perforations into the oil string. It will have its maximum value fixed by the thickness of the sand which is to be exploited, but will depend on A and on the condition of the space between the outside of the oilstring and the face of the sand.

In the later stages of the well's life this value may be very effectively reduced by heavy drilling mud settling down and

choking up this space. Other conditions being equal, the rate of flow of oil will be proportional to the thickness of the sand producing.

S = Saturation factor.

H = Height above the level of the sand to which oil must be lifted. With a given available energy the rate of flow will be inversely proportional to the lift.

P_1 = Back pressure at the well head controlled by the size of the bean.

P_2 = Back pressure controlled by the size and depth of the flow string.

P_o = Effective rock pressure. Is a mean pressure determined by the initial rock pressure, and the bottom hole pressure and the radius of influence.

I = Impedance to flow induced by the particular characteristic of the sand and viscosity of the oil.

V_1 = Total volume of gas produced; r=radius of influence.

V_2 = Total volume of oil produced.

R = The ratio of V_1 to V_2.

Assuming, in the first case, that the well is in perfect mechanical condition, and that the saturation of oil in the sand does not change. Then the group of factors $\frac{ATS}{H}$ will be of constant value, and the above formula can be reduced as follows :—

$$Q \propto K_o \times \frac{P_o}{(P_1+P_2)\ I\ (V_1+V_2).}$$

Given now that a well is flowing at a certain rate Q against a tubing head back pressure P_1 and a back pressure P_2 due to the friction in the tubing.

Oil is moving towards the bottom of the well with some average velocity, and to overcome the impedance to flow induced a certain pressure differential is created from the point of maximum pressure to the face of the sand. A certain volume of gas is being liberated for every foot that the oil is driven owing to the drop in pressure.

The bean is now increased with a view to increasing the rate of flow.

The back pressure will be reduced and the initial effect will be to increase the velocity of the oil and gas in the sand.

But this will cause an increase in I followed by a steepening of the pressure differential and a liberation of a larger volume of gas for every foot of movement of the oil.

The resistance of the sand to the movement of the oil being greater than its resistance to the movement of gas, the liberated gas will tend to force its way ahead of the oil and still further to increase the impedance by the formation of gas locks in the sand.

The higher tubing velocities set up by the increased volume of gas will increase P_2.

These retarding influences may more than balance the reduction of the back pressure initiated by the bean change, so that the final result may be actually to reduce the rate of flow.

A well coming under the attention of the author produced, on the third day after it was brought into production, 450 barrels on a 19/32 bean with approximately 1,200,000 cu. ft. of gas. The average tubing pressure was 292 lb. per sq. in. It was beaned up to a $\frac{3}{4}$ in. bean in order to increase production. The back pressure was reduced to 200 lb. per sq. in., and the well produced in the next 24 hours over 2,000,000 cu. ft. of gas with 420 brls. of oil. When the well was beaned back to a No. 18 bean after about 36 hrs., its rate of flow had dropped to 317 brls. per day, with the gas production still well over 2,000,000 cu. ft.

It is probably the fact that where these conditions prevail, the rate of flow of oil is controlled primarily by the impedance to flow in the sand.

There will be a critical point beyond which any reduction in back pressure will not result in an increase in the rate of flow.

To embody the principle of decline in the relationships of these factors it is only necessary to consider Q as having a constantly diminishing value.

With reference to Fig. 1 it will be assumed for simplicity that the sand body is bounded by two parallel planes, and that the oil is driven into the well from a continuously widening circle around it. Outside this circle of influence the conditions are static and the sand retains its original rock pressure.

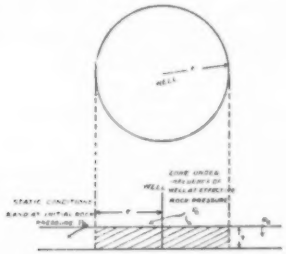

FIG. 1.

If r is the radius of the circle of influence and T the thickness of the sand producing then the volume of the sand within the circle of influence is $\pi r^2 t$.

As oil and gas are produced from the well this volume of sand increases and the effective rock pressure decreases—*i.e.*,

$$\pi\ r^2 t = K\ (V_1 + V_2) = K_1 \frac{1}{P_o}.$$

Impedance increases with the radius of the circle of influence and with the square of the average velocity of the oil and gas in the sand—*i.e.*, $I = K_3 r v^2$, where v is the average velocity of the oil and gas in the sand, and K_3 is a constant depending on the resistance of the sand.

It is evident from the above relations that the impedance increases with the total volume of oil and gas produced. It will also be realised that to maintain the same rate of flow the velocity v must increase with the radius of influence. Where t is small, the radius of the circle of influence must increase more in proportion to the volume of oil and gas produced, and as I increases with r it means that in wells in which the thickness of sand is small, impedance will increase more rapidly with the total volume of oil and gas produced.

The total recovery will depend on the volume of oil produced per unit increase in the radius of influence. That is, V_1 must be kept as small in proportion to V_2 as possible.

The formula can therefore again be modified as follows :—

$$Q = \propto K \frac{P_o}{(P_1 + P_2)\ IR},$$

where R is the ratio of the total gas production to the total oil production.

Applying, firstly, the condition that the thickness of sand is small, then :

(*a*) When Q is high the increase in I is excessive so that Q must decline rapidly.

(*b*) In order to diminish I, P_1 must be high so that Q will be lowered.

The conclusion is that when producing from thin sands high rates of flow cannot be maintained and a flat decline can only be obtained by considerably reducing the rate of flow.

Applying, secondly, the condition that the sand is of high resistance, then :

(*a*) When Q is high, the increase in I is excessive, causing an increase in R followed by a decrease in P_o. Q must therefore decline rapidly.

(*b*) In order to check the above P_1 must be high so that Q will be lowered.

The conclusion is that when producing from high resistant sands, large rates of flow cannot be maintained and a flat decline can only be obtained by considerably reducing the rate of flow.

If both the above conditions exist, then the rate of flow may have to be very small to obtain a flat decline.

Fig. 2 shows the decline curves for six wells. The wells 1, 2 and 6 are producing from the medium gravity upper Cruse Zone and the wells 3, 4 and 5 from the light gravity lower Cruse Zone.

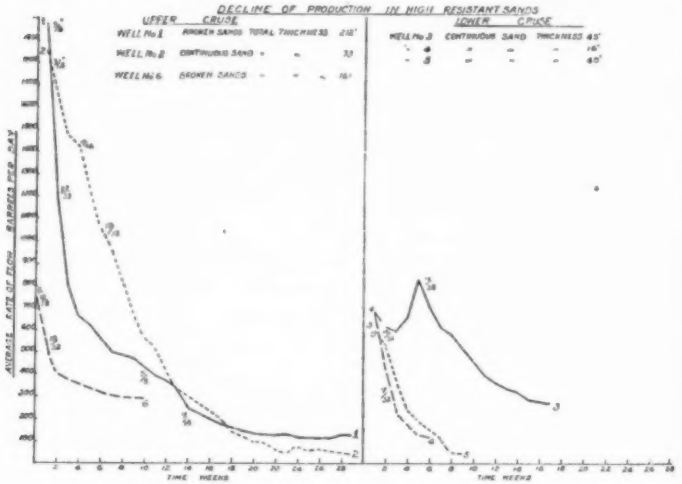
DECLINE OF PRODUCTION IN HIGH RESISTANT SANDS
UPPER CRUSE
LOWER CRUSE
WELL No 1. BROKEN SANDS TOTAL THICKNESS 210'
WELL No 2 CONTINUOUS SAND " " 33'
WELL No 6. BROKEN SANDS " " " 161'
WELL No 3 CONTINUOUS SAND THICKNESS 45'
" 4 " " " 16'
" 5 " " " 45'
AVERAGE RATE OF FLOW BARRELS PER DAY
TIME WEEKS
TIME WEEKS

FIG. 2.

It will be noted that the thickness of sands encountered in the upper Cruse wells are much greater than in the lower Cruse wells. Probably the saturation factor also varies considerably in the different sands, so that the wells should not be compared by their relative productivities but from the nature of their decline curves. Strict well head control had not been applied to wells 1 and 2, and it is highly probable that these wells were beaned up above their critical points. That is to say, the rates of flow would have been as high on smaller beans, in which case the flattening points on the curves would have been reached earlier. Wells 1 and 2 on the attached graph are examples of two wells which were produced on large beans for some considerable time during the early stages. The precipitous decline will be observed until the rate of flow is reduced to a small fraction of the initial rate.

At well No. 6, where strict control was employed, the flattening point of the curve is much closer to the initial point.

Well No. 3 is an example during the first four weeks of the influence of the factors A and T on the rate of flow. Part of the perforations were plugged off until the well eventually broke through and cleared itself.

It would appear from the nature of the curve that if the well had been restricted to about 600 brls. just after it was cleaned out on the third week, its decline might have been further arrested.

Precipitous declines have occurred in wells 4 and 5 in spite of the bean control employed.

The curve for well No. 5 is difficult to explain and may be due to a low saturation factor and to the fact that there are two depleted sands open above the sand actually producing. Increased back pressure would perhaps tend to drive oil into these sands. Well No. 4 appears to be a case where the combination of thinness and resistance in the sand makes it only possible for the well to maintain a small rate of flow.

The gas production has been lowered and the ratios improved on wells 3, 4, 5 and 6 which are considered here. If the reasoning put forward with regard to impedance is correct, then it is almost certain that the decline curves would have been steeper and more prolonged and less oil would have been produced had these wells been flowed on larger beans.

The type of decline curve which will give the greatest total recovery is difficult to determine, more especially as has been indicated in this paper, when sub-surface factors have a predominant control in this decline.

Gas-oil ratios have, therefore, an even greater significance under these conditions than when production is being obtained from larger and more porous sand bodies.

The magnitude of the increase in gas-oil ratio for a given decrease in back pressure will give an indication of the extent to which impedance controls the situation.

The final point to be realised is that wells controlled by small beans are not necessarily being restricted in their rate of flow of oil.

Acknowledgment is made to the Trinidad Petroleum Development Co., Ltd., for permission to use data obtained from their production.

DISCUSSION.

Mr. R. Godfrey said that where wells under volumetric control were concerned, he agreed with the conclusions arrived at, but did not quite agree with the method employed to reach them.

In the first equation, did the author mean to imply that by using $\frac{3}{8}$ in. perforations instead of 5/16 in. we would get a bigger production, and that the height which the oil must be raised is a controlling factor of rate of flow in the initial stages of the well ? If a well is beaned, there is always an excess of energy available.

Within reasonable limits he thought that well head control was only relative to rate of flow, inasmuch as it controls bottom hole pressure. That being the case, it would be preferable to treat the subject as two separate phases.

(1) The bringing of the oil into the bottom of the well.

(2) The raising of the oil to the surface.

If the whole of the available energy is dissipated in delivering the oil into the bottom of the well, there are means of applying energy to lift it.

Considering the first phase only, the rate of flow per unit thickness of producing sand could be expressed :—

$$Q_t = 2\,\pi\,C\,\frac{r_1}{r_0}\,\phi r\,dr$$

where Q_t = Rate of flow per unit thickness.
C = A constant.
ϕr = Some functions of r.
r_1 = Radius of influence.
r_0 = Radius of well.

$C+\phi r$ could be developed taking into account pressure, velocity, viscosity, porosity, etc., and he thought that a formula worked out along those lines would give one a better conception of the actual conditions existing in the sands.

Relative to the subject Mr. Godfrey said that when discussing the performance of a well he had often felt that there was something missing, and that was a decline factor. He thought he was safe in saying that the production from a well under volumetric control approximately followed the law $P=Ct^n$.

Where P=production in time t.

For any set of conditions n is constant and could be expressed as the decline factor.

When put in the straight line from $n = \frac{d \log P}{d \log t}$ and can easily be determined by obtaining the tan of the angle which the curve makes with the horizontal when P and t are plotted on double log paper.

He thought a factor of this description, if universally adopted, would fill a long felt want.

Mr. M. A. ap Rhys Pryce said that he thought the author had really got down to the fundamental factors that were influencing the flow of oil. The outstanding thing in that paper was,

to his mind, the introduction of the word impedance. That term impedance which the author had introduced was one new to him, and he thought probably new to production literature. He had never seen it used before. He thought the author was to be congratulated on its introduction. The term impedance could be used to cover all the terms and factors influencing resistance to movement of oil and gas in the ground, which they had in the past generally referred to as resistance to flow. This included capillary action, the characteristics of the sand, the friction in the sand, the surface tension of the oil and so forth. Herold had divided oilfield production into three groups: hydraulic control, volumetric control and capillary control. Personally, he took exception to Herold in his three divisions in that he himself only recognised two fundamental divisions of control as sources of energy—*i.e.*, energy from water pressure and energy from gas pressure. Capillary action in the sand was really a component of impedance and could not be looked upon as control in itself. In a case where capillary action was responsible for 80 or 90 per cent. of impedance, then it certainly would have a controlling influence to flow, but it was not a fundamental type of control to his mind.

He invited the author's opinion on the point as to whether the capillary control introduced by Herold was not really a component of impedance and that the two fundamental controls were hydraulic energy and gas energy.

Another interesting point made by the author was where he stated "that to maintain the same rate of flow the velocity v must increase with the radius of influence." That was an extremely important point and one that was very often lost sight of. He made a rough calculation before coming to the meeting. He had not time to check the figures, but they would serve to illustrate the point.

Assuming they had 50 ft. of sand containing 20 per cent. voids; in other words the sand was 20 per cent. porous and filled with oil and gas in solution. For the purpose of this calculation he had ignored free gas and assumed it was all in solution. Assuming that a well was drilled into this 50 ft. of sand, and that its porosity was 20 per cent., and that the well produced 2000 brls. of oil in 24 hours, each unit of oil would travel an average distance of 13 ft. In order to maintain this rate of flow, that 2000 brls. of oil would have to be replaced by another 2000 brls., which would have to travel an average of $22\frac{1}{2}$ ft., and if the average rate of production was to be maintained, the third 2000 brls. of oil would have to travel 29 ft. In other words, if a well continued at that rate of

flow, the increase in distance to be travelled for the second 24 hours production was something like 70 per cent.

The increase in impedance due to friction in the case of the second 2000 brls. would therefore be considerable. That, he thought, for tight sands as are found in Palo Seco was normally the reason for the very rapid declines. He did not believe that in Palo Seco Jamin action had so much effect as plain friction due to the tightness of the sand and surface tension of the oil. He would say that in his opinion plain friction was one of the major factors affecting the phenomenal declines recorded in some of the graphs exhibited. In that connection he had experience of a few wells in Palo Seco. Out of 12 wells that were commercial, the two best had by far the smallest initial production coincident with the flattest declines and the largest accumulative production over a length of time. There was no record why these two wells had such small initial productions. They had never been produced on a very large bean, but, on the other hand, neither was a very small bean used. In the case of one of them it was probable that paraffin was the cause of restricted production, as when it was cleaned out they found that the average diameter of the tubing had been paraffined up to $\frac{1}{4}$ in.

There was one mechanical factor that had not been referred to by the author. It was with regard to flowing wells too hard at the start. In a field where the oilsands were largely interspersed with shale it seemed to him a serious danger that, if the impedance was so great that the initial production of the well was not immediately replaced by oil following up from further back in the formation, the sand immediately around the casing would be dried out and collapse, allowing shale to fall down round the perforations and shut off the oilsands. He would like to know if the author had any experience of this mechanical factor which had not been mentioned in the paper.

With further reference to the question of impedance, the argument was often advanced that the best method of reducing I was to reduce the back pressure and let free the gas as much as possible and thereby break down the interstices between the sand, thus inducing greater flow.

Theoretically I was made up of capillary action and friction which was dependent largely on surface tension and viscosity. If there must be an increase in the flow of the well, the greater must be the velocity in the sand, and therefore the greater the impedance due to both capillary action and friction. Capillary action cannot be present unless there was free gas present in the sand.

Reducing back pressure very rapidly always resulted in the

liberation of free gas as could be seen in the rapidly increasing gas/oil ratio of a well so handled. Provided a well is not drilled in the gas cap, but drilled anywhere down the flank, the gas would be in solution to begin with. If a well was produced fast or wide open, all the factors which were included in I must increase, and therefore I must get bigger and therefore the resistance to flow must increase. There were cases where wells had gone wild and produced very large volumes of oil, not only in Palo Seco but in other fields, and this was often put forward as an argument in favour of flowing wells wide open.

On going into this question in other fields one found that the well which did this was nearly always a discovery well or semi-discovery well in virgin territory with a very high bottom hole pressure which would have made a large volume of oil, no matter how it was handled. In virgin territory with a high bottom hole pressure the impedance is a small factor, but as soon as the pressure in the structure has been reduced to any appreciable extent the impedance becomes a very great factor indeed. Appreciation of this fact disposes of the argument often put forward in favour of flowing wells wide open.

In conclusion, it was a fact that I must increase with the velocity of the oil through the sand, and therefore increasing the rate of production must inevitably increase the impedance factor.

Mr. G. A. Walling said he thought that a barrel of fluid at the surface was actually less than a barrel at some point in the formation. A test taken with a pressure bomb on some oils at various points in the well shows that their volume could shrink as much as 10 per cent. when the gas went out of solution. Shrinkage was dependent on the amount of gas that was in solution. It was rather difficult to look at the matter from the point of view of one barrel moving through the formation. The actual volume of liquid moving through the formation is continually changing on its way to the foot of the hole. The liquid is turning into gas on its way through the formation. He did not think that fact had been taken into consideration in the paper read so far.

He agreed about the critical back pressure and that getting below that pressure did not increase the production. One got an example of that in the later stages even in a pumping well. A pump could be set 200 ft. off bottom, and lowering the pump below this point would give no increase in production. It was rather difficult to determine in practice what was the critical back pressure exactly at various stages in the life of rapidly declining wells submitted as examples in the paper. The critical back

pressure would be decreasing in some definite relation to the declining rock pressure.

Mr. C. E. Capito said that the author had stated that the type of decline curve which would give the greatest total recovery was difficult to determine, but could not that be done by trial and error in the same sand ?

He was of opinion that the damage causing rapid decline was done in the first few hours of production when cleaning a well. If it was allowed to flow too fast, it was liable to bring sand in, and where there were thin sand bodies the roof collapsed. He had made a small calculation. Assuming a well was producing 400 brls. of oil and giving 1 per cent. sand it would produce $22\frac{1}{2}$ cu. ft. of sand in the first 24 hours. If they took 100 ft. of sand, 50 per cent. of which was true sand and the rest shale, that $22\frac{1}{2}$ cu. ft. of sand was equivalent to taking out 2·73 in. of sand from the well face in the first 24 hours when the hole being drilled was $6\frac{1}{8}$ in. diameter. Such depletion of sand round the well would allow the roof to fall in and cover the sand face. High gas-oil ratios also steepened the decline by increasing viscosity of the oil, and, incidentally, as Mr. Patterson remarks, making gas locks.

Fancher, Lewis and Barnes* state that the flow of fluids through sands resembles flow through pipes with which some of Herold's theories did not appear to fit in. Herold states that the initial radius of influence from a well rapidly decreases instead of increases, whereas if the flow through a sand was like flow through a pipe the radius of influence should increase instead of decrease.

The Chairman said that he was in agreement with the author's basic conclusions, and that any remarks he made were not intended to imply criticism of these conclusions.

The author stated that a certain volume of gas was liberated from the oil for every foot that the oil is driven. Although this was true in many cases, there were oilfields in which the saturation pressure was much lower than the reservoir pressure. Thus Captain Comins had shown that in the Persian fields this condition had been proved to exist. If in such cases the differential between effective reservoir pressure and bottom hole operating pressure was maintained at a lower figure than the differential between reservoir pressure and saturation pressure, one is assured that all gas produced has accompanied its quota of oil to the well, and, moreover, that there is no liberation of gas within the reservoir rock. Similar conditions are known to exist in the East Texas field where even with the colossal extractions and reservoir pressure

* *Proc. World Petr. Congr.*, 1933, **1**, 322–333.

drop it is calculated that there has been no liberation of gas within the producing sand.

The author states that to diminish I, P_1 must be high so that Q will be lowered. He considered that the author might have said P_1 or P_2, as this would allow of variation in the setting depth of the tubing, variation in the size of the tubing string and the use of bottom hole chokes.

He felt some misconception existed as to Herold's definition of his three controls—hydraulic, volumetric and capillary. He noticed that several speakers regarded volumetric control as a gas energy control. This was not the case. Volumetric control is an hydrostatic control with a declining pressure head. Anyone was at liberty to differ from Herold's conception of the performance under the various controls, but he considered that his basic definitions must not be misconstrued.

Mr. Patterson, in reply, said that Mr. Godfrey had asked whether the first equation implied that bigger production would be obtained by using larger diameter holes. He had been careful to explain in the definition of A that the factor considered was the total areas of perforations open to the producing sand, and it was quite possible to obtain a larger open area by using a large number ot small holes than by using a smaller number of large holes. The rate of flow should certainly increase with the open area achieved in the design of the pipe, other conditions being equal.

He considered that the formula suggested by Mr. Godfrey was too complicated for practical purposes, and that the actual linear measurement of the radius of influence could not be calculated with any sort of accuracy.

He agreed with Mr. Rhys Pryce in his conception of capillary control as a component of impedance, and the constant K_3 as given should include this factor. It should also be added that the value of K_3 might change at any time in the life of the well.

With regard to his remarks on the mechanical factor, the author had allowed for this in the formula but had not discussed it in detail, as it would have made the paper too long. It was certainly true that in Palo Seco a great deal of trouble was experienced from shale mud choking up the perforations, causing a substantial reduction in the rate of flow if not a total cessation. He considered that it was in part due, as Mr. Rhys Pryce suggested, to opening a well up too much in the initial stages.

Mr. Capito had suggested that the type of decline curve which would give the greatest total recovery could be found by trial and error in the same sand. What the author meant was the shape of the curve relative to its initial rate of flow. It was observed that the total thickness of the sand in the upper Cruse was much

greater than in the lower Cruse. It was also probable that the saturation factor varies considerably in the different sands. Therefore the shape of the curve relative to its initial rate, would, even to give the maximum yield, be different in each case, and it was accordingly difficult to know what shape of curve to aim at in any particular well.

The simplest and most practical method would be to flow the well always at approximately its critical bean, and in the case of a new well to bean down rigidly to start with and then to bean up by quick stages until the gas-oil ratio showed an upward jump. This, of course, assumes that the well is not subject to severe sand trouble when restriction of sand becomes the dominating factor.

In reply to Mr. Walling the author said that he had assumed that there was no appreciable change in the volume of oil under reduced pressure. He had treated oil and gas separately, and accordingly an increase in volume of the mixture was simply the same volume of oil plus an increase in the volume of gas, some of which came out of solution. This feature had been dealt with.

In concluding the author said that the possibility of increasing the porosity of the sand had been considered. The theory in this case was to maintain the rate of flow sufficiently high in the initial stages to allow the smaller sand particles to be carried to the well and produced at the surface. The object of this would be to break down the compactness of the sand and thereby to reduce the impedance.

It has not been found possible to do this in practice with the type of sands under discussion. It was the general experience that even when wells were flown "open," the sand produced was so small that no appreciable change could be expected in the texture of the sand body.

Also, it has been pointed out that where the impedance factor is predominant, unrestricted control does not increase the flow of oil, but decreases it, and it is on the increased movement of oil in the formation that the carrying of silt must depend.

Apart from this there was the danger of collapsing the liner or production string. This was an important consideration, especially where small diameter strings were used.

REVIEWS.

PROBLEMS OF PETROLEUM GEOLOGY: A SEQUEL TO STRUCTURE OF TYPICAL AMERICAN OIL FIELDS. A SYMPOSIUM. Edited by W. E. Wrather and F. H. Lahee. Tulsa, U.S.A., American Association of Petroleum Geologists. 1934. (London: Thomas Murby and Co. Pp. 1073. $6.0.)

IN 1929 the Association of Petroleum Geologists published two volumes under the title of "The Structure of Typical American Oil Fields." These contained detailed descriptions of a large number of individual fields, and although a large number of contributors, each a master in his own sphere, combined to produce these volumes, the initiative for the collection of the papers lay with Sidney Powers. Sidney Powers was the leader of a small Research Committee of the Association formed to enquire into the origin of oil, its migrations and its accumulation, and the first stage in this research was a general survey of facts of observation; the second stage was to be analytical and critical. The two volumes above mentioned covered the factual survey, and the volume under review was intended to cover a wide range of problems connected with petroleum geology. Unfortunately the untimely death of Sidney Powers took place while the papers which form this book were being collected, and instead of the work appearing under his editorship it is published as a memorial to him. "The dedication of this volume to his memory is scant enough recognition of the prodigious amount of work he accomplished in a relatively short span of life, but it is unquestionably the type of memorial by which he would have preferred to be remembered."

The book is divided into seven parts, each part, with the exception of the first which is historical, dealing with one specific problem, and each part introduced by a foreword by a recognised authority in that particular sphere. The subjects chosen are: Origin and Evolution of Petroleum, under which title comes Origin, Carbon Ratios and Variation of Physical Properties; Migration and Accumulation of Petroleum; Relations of Petroleum Accumulation to Structure; Porosity, Permeability, Compaction; Oil-field Waters; Sub-surface Temperature Gradients.

Such an immense collection of valuable fact and theory is assembled under these headings that one feels almost ungracious and ungrateful in being unsatisfied with the result, and yet it is the case. The subject-matter lacks co-ordination, and the critical analysis of each group of papers in the various forewords is quite insufficient to do value to the subjects concerned, with the result that the work in reality still belongs to the factual phase of the Research Committee's original project. If this were to be accepted, and if we could hope for a subsequent volume of an entirely critical and analytical character, then all praise to the present work when put into its proper place in the scheme.

The problem of the origin of oil is well discussed by Trask, Hammer and Snider. The research into the nature of recent sediments by Trask seems to have almost completely eliminated the possibility of oil being formed as such at the time of deposition of the sediments, but beyond this negative fact we still lack any evidence on the details of the origin. The subsequent action of anærobic bacteria on entombed organic matter is perhaps generally favoured, but against this there is the slow distillation hypothesis. Wallace Pratt has expressed his opinion very ably and vividly, though perhaps not convincingly, in favour of a combination of cracking and hydrogenation. The first stage is the formation of gases, principally methane, and of a heavy oil from the original organic material, and this heavy oil may later be "methylated" to decrease its carbon-hydrogen ratio and so improve its

quality. Barton supports this general hypothesis with a mass of evidence from the Gulf Coast province, and states his view that all crude oil starts as a heavy petroleum, and that "temperature, pressure and perhaps other factors act on the petroleum to produce with the passage of time a slow, evolutionary transformation . . . from heavy crude oil . . . through a progressively lighter series of oils, into paraffin-base crude oils composed predominantly of gasoline and kerosine."

Unfortunately, most rich oilfield provinces have such an embarrassment of possible source rocks that a simple scheme such as postulated by Barton can rarely be observed.* In many fields oil probably originates at a number of levels, and subsequent migration may cause a mixing of different types and so complicate the picture. Ventura Avenue field is a case of a field which works the opposite way to Barton's scheme for the Gulf Coast. In the Gulf Coast there is a general improvement in quality of the oil with depth and age, whereas at Ventura Avenue the gravity increases from 56° in the shallow sands, 300 to 1600 ft. depth, to 29° to 32° in the lowest sands down to 8000 ft. Taff explains the conditions at Ventura Avenue by allowing upward migration through clay and silt to have been effective in altering the gravity; but more research work on this possibility is required before it could be accepted as an important factor. He is forced to suggest also a higher source in the Pliocene, and also to allow contact with edge-water to explain many anomalies.

The problems of the Rocky Mountain province are well discussed from all aspects, character of oil, structures, and the possible effects of a mobile water system on accumulation of the oil and on the oil itself. This is perhaps the most interesting section of the book, for although the Rocky Mountain province ranks lowest commercially among the oil-bearing regions of North America, it surely takes a high place in respect of its general interest and the difficult problems which it presents. The foothill phase of the Rocky Mountain front contains all the pre-requisites of an important oilfield belt. Stratigraphically, it has a well-developed geosynclinal character showing continuous and thick sedimentation, with only unimportant local non-sequences or unconformities, from middle Palæozoic until early Tertiary. Structurally, it is in general a normally folded zone, the degree of folding ranging from steep faulted folds along the front of the great overthrusts of the Rockies proper to broad, gentle folds as the eastern foreland of the Rocky system is approached. This foothill zone extends from New Mexico to the Canadian border in the United States, a length of about 1000 miles, and north of the border it continues through Alberta and N.E. British Columbia. Oil shows and bituminous rocks are widespread both in geographical and stratigraphic distribution. Excellent reservoir rocks exist throughout and yet in spite of all these theoretically favourable factors only one single field, namely, Salt Creek, is in the major field category, and this field alone has produced 50 per cent. of the total production of the region up to date.

A glance at a structural map of California shows how high is the proportion of oil fields to suitable anticlines, but what a striking contrast is presented by the Rocky Mountain province. Here the number of favourable structures is legion, and many are of such a size that major oilfields might well be expected, and yet the total production for the whole province is at present only about 97,000 barrels per day. It is true there is some shut-in production, but this is because of small uneconomic wells and low-grade sulphurous crude.

* For a criticism of Barton's hypothesis in the light of Rumanian experience, the reader should read Krejci-Graf's contribution in "Petroleum," 1933, **29**, 5.

In a paper on the relation of structural history to oil accumulation in the Rocky Mountain district, H. F. Davies relates the presence of important fields, such as Salt Creek, Lost Soldier and Grass Creek, to the fact that they lie within the area of maximum thickness of both Carboniferous and Cretaceous deposits. The lack or small amount of oil in Cretaceous beds elsewhere "may be explained by flushing or oxidation before the formations of the anticlines," but unfortunately the amount of evidence presented is quite insufficient to allow the reader to form any independent conclusion on this point. The importance of the fresh or brackish water system is later discussed in the section dealing with oilfield waters and flushing and oxidising effect on the oil is pointed out, but here again one would like much more detailed evidence to support such an important hypothesis. In fact, a study of the literature of the Rocky Mountain region provokes a desire for a much fuller treatment of its negative oil geology, that is not so much for descriptions of such oilfields as do exist as for more details of the failures, of the structures which have been tested and found wanting.

It is impossible to do justice in a short review to a book which must for many years have an important place in the literature of oil geology. If it falls short of expectations in some sections, as for example, in the articles on the older Appalachian fields, it is because these are descriptive rather than analytical; and it is to be hoped that the good work so ably begun by Sidney Powers as leader of the Research Committee of the Association will be continued in the future.

G. M. LEES.

THE PRINCIPLES OF MOTOR FUEL PREPARATION AND APPLICATION. Vol. I. A. W. Nash and D. A. Howes. London, Chapman and Hall, 1934. Pp. 538. 30*s.* 0*d.*

The "Principles of Motor Fuel Preparation and Application" is being published in two volumes, and the present review deals with Vol. I. only, which is principally concerned with the methods adopted in the manufacture of motor fuels, alcohol fuels, and synthetic fuels, but also includes a chapter on storage, insurance and distribution. The authors have produced a very comprehensive treatise, dealing with all the important aspects of the subject, and the book represents the most complete and thorough treatment yet published on this subject.

The first chapter, on Distillation, gives a description of the principles underlying fractionation, both batch and continuous, and steam, vacuum and pressure distillation.

The second chapter is primarily concerned with a description of the design of distillation equipment, including pipe-stills, fractionating columns, heat exchangers, and the theory underlying the operation of these forms of equipment.

The third chapter deals with the production of motor fuels by cracking and gives a fairly complete summary of such processes as the Cross, Dubbs, and Gyro processes.

Further chapters deal with the extraction of gasoline from natural gas by compression and absorption methods, and the refining of motor fuels, including acid refining, doctor treatment, hypochlorite treatment, and a number of special processes.

The chapter on storage, distribution and insurance, gives an account of the various types of tankage adopted, of fire-fighting equipment, and also deals with the transportation and distribution of petrol.

The production of benzole and the specifications in various countries is

also described, and the production of motor fuels by the hydrogenation process.

A very complete survey of alcohol fuels is given in a further chapter, comprising both ethyl alcohol and methanol fuels, together with some account of the use of alcohol on the Continent in motor fuels. This particular chapter also includes a number of sections on the use of alcohol in motor fuels, which summarises the present state of knowledge on this subject.

The last chapter in Volume I. deals with the production of synthetic fuels and auxiliary supplies.

The general production of the book is satisfactory. A system of indexing has been adopted referring to numbered paragraphs rather than to the pagination, which has been worked out satisfactorily.

References are made in the paragraphs to the literature of the subject, and these references are placed at the end of the various chapters. We feel that it would have been advantageous for the literature references to have been placed at the foot of the pages. A number of supplementary literature references conveniently grouped under various headings form a valuable supplement to the information given in the chapters.

Subject, patent and name index has been included, and those published in Volume I. relate to both volumes.

The "Principles of Motor Fuel Preparation and Application," Vol. I., represents a very adequate summary of all the important work in this particular field, and great care has obviously been taken to make the book authoritative by including only work considered to be of permanent value.

F. H. Garner.

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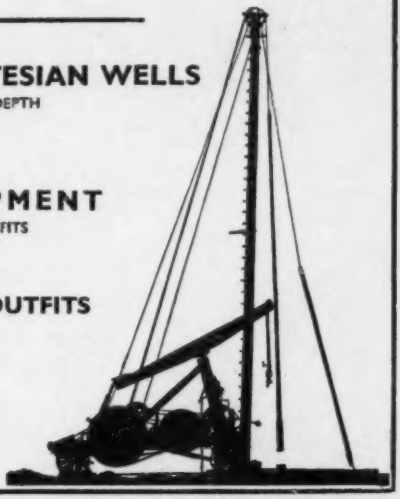

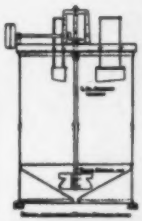

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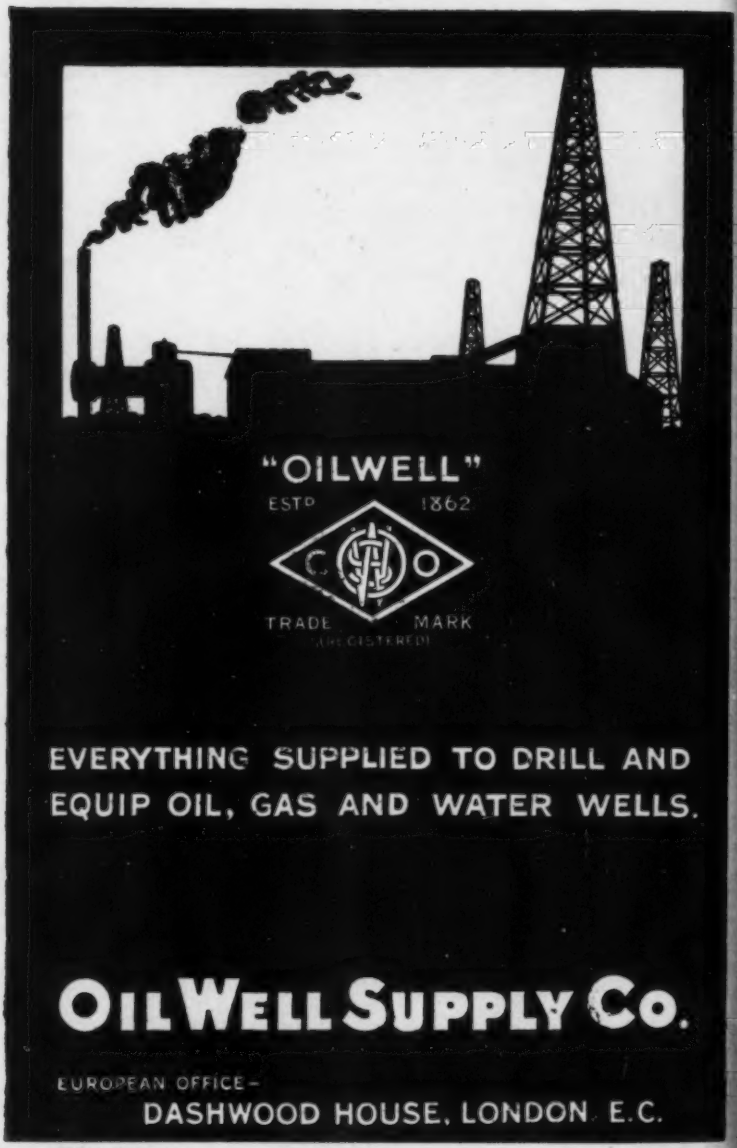

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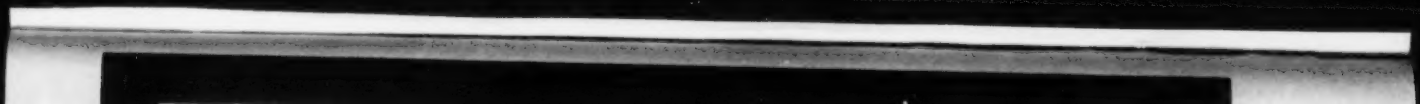

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AMERICAN SOCIETY FOR TESTING MATERIALS. A.S.T.M. Standards. Part I. Metals; Part II. Non-Metallic Materials.

BRITISH STANDARDS INSTITUTION. B.S.S. No. 397–1933. Leclanche-Type Primary Cells.

—— B.S.S. No. 513–1933. European Larch Poles for Transmission Lines.

—— B.S.S. No. 514–1933. Baking Insulating Vanish (Bitumen Type) for Electrical Purposes.

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—— B.S.S. No. 523–1933. Phenol.

—— B.S.S. No. 524–1933. Refined Cresylic Acids, Grades A and B.

—— B.S.S. No. 525–1933. Fibre Cores for Wire Ropes.

CANADA DEPT. OF MINES, BULL. 727–3. Report of Experimental Work on the Hydrogenation of Canadian Coal, Coal Tar and Bitumen for the Production of Motor Fuel.

GARNER, F. H. (Editor). Modern Road Emulsions.

INSTITUTION OF MECHANICAL ENGINEERS. Vol. 124 of Proceedings.

JUNIOR INSTITUTION OF ENGINEERS. Vol. XLIII. of Journal and Record of Transactions. 52nd Session, 1932–33.

PETROLEUM REGISTER, 1933.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.

TRINIDAD BRANCH.

THIRD ANNUAL DINNER.

The Third Annual Dinner of the Trinidad Branch of the Institution of Petroleum Technologists was held on October 21st, 1933, at the Queen's Park Hotel, Port of Spain, Trinidad.

The chair was taken by Mr. Hugh C. Scott, Branch Chairman. The principal guest was His Excellency the Governor, Sir Claude Hollis, K.C.M.G., C.B.E., who was attended by Major H. Stedman, O.B.E., A.D.C. Among the guests were the Hon. S. M. Grier, C.M.G., Colonial Secretary; the Hon. F. Gordon-Smith, Attorney-General; the Hon. J. Strachan, C.M.G., Director of Transport; Mr. Geoffry Evans, C.I.E., M.A., Principal of the Imperial College of Tropical Agriculture; and Mr. John Pendrich, President of the Trinidad Chamber of Commerce.

"The King."

The toast of "The King" was proposed by the **Chairman** and received with musical honours.

"The Institution of Petroleum Technologists."

His Excellency the Governor, in proposing the toast, said: I rise with very great pleasure to propose the toast of "The Institution of Petroleum Technologists," but I cannot help feeling that in order to do justice to this toast I require what Shakespeare terms, "That glib and oily art, to speak and purpose not."

Trinidad holds the proud position of being the principal producer of crude oil within the British Empire, and last year petroleum products formed over 56 per cent. of the Colony's total exports. The oil industry of Trinidad is therefore not only in a large measure responsible for the Colony's prosperity, but it is also of considerable Imperial importance.

We live in an oil age. This generation is dedicated to the spirit of petroleum, which represents progress, adventure and achievement by air and land and sea. Few people, however, realise what a large number of products owe their origin to petroleum. I am credibly informed that they number some hundreds, and they range from asphalt to chewing gum, from coke to cosmetics, from lubricants to luminants, from vaselines to varnishes, from soaps to solvents, from insecticides to floor polishes, from lipsticks to explosives, and from cleaning spirit to a purge.

To many of us the petroleum technologist is a peculiar being, and we are puzzled as to what he may be. Two years ago, when proposing this toast, I endeavoured to explain that he was a man of many professions, but I am relieved to learn that a distinguished petroleum technologist recently admitted that there are almost as many breeds of petroleum technologists as there are breeds of dogs. They may, perhaps, be likened to the 57 different varieties of sauces which the famous Mr. Heinz advertises for sale.

The application of science has had a profound influence in shaping the modern world, and the late Lord Moulton once said that the progress of human power over nature was achieved by workers of three different classes, the scientific investigator, the inventor and the technologist. I think that the contrast between the scientific discoverer and the technical giants who follow him cannot be better expressed than by two quotations from "Paradise Lost." You may remember that when Satan toiled through the vast void to reach our earth he is thus described:

> "So he with difficulty and labour hard
> Moved on—with difficulty and labour he."

But once he had passed through the wide expanse, his two companions, Sin and Death:

> "Following his track—such was the will of heaven—
> Paved after him a broad and beaten way
> Over the dark abyss."

The one, as a pioneer, finds his way with doubt and difficulty through the unknown till he unravels the mystery and reveals the truth that he has been seeking, and that is his triumph. But the triumph of the others is the broad and beaten way that they make after the truth has been arrived at, so that all can avail themselves of its results.

The oil industry, like many others, has been, and still is, in trouble, but it is certainly not suffering from lack of technical skill. It is suffering from economic causes which are world-wide, and it is from the economists rather than from the technologists that relief may be expected. A solution of the over-production problem should not be beyond the powers of the brilliant men who control the destinies of the oil companies, and I understand that this question was considered at the World Petroleum Congress which was held in London last July. I should like to suggest for my hosts' consideration that, so far as trade with Canada is concerned, they might strengthen their own position and make it easier for the Government to negotiate on behalf of the Trinidad industry as a whole, if they were to set up a single selling agency in the Colony. There are doubtless difficulties in the way, but the difficulties of the present time call for a co-ordinated effort to

overcome the forces of depression, and it is only by the closest co-operation with each other and with the Government that the future of individual companies and producers can be assured.

Gentlemen, I raise my glass to the Institution of Petroleum Technologists, and in doing so let me remind you of a saying of one of the old classics : " Everything is soothed by oil, and this is the reason why divers persons send out small quantities of it from their mouths, because it smooths every part which is rough."

Mr. Hugh Scott, in reply, said : I feel that while it is true that this function is sponsored by the local branch of the Institution of Petroleum Technologists, it must be considered in some way representative of the petroleum industry of Trinidad.

It is true that our activities are more confiend to the scientific side of industry, but industry is becoming more and more dependent on science and scientific research. One has only to glance at any journal of industrial chemistry to comprehend the ramifications of this one branch of science into all walks of industrial life.

The petroleum industry is one which probably utilises a greater number of the various branches of science than any other. To sub-divide the genus of petroleum technologist into all its constituent species would be about as difficult as constructing the genealogical tree of the average Trinidad dog. I wish this statement to be considered as a comparison and not an analogy.

The petroleum industry is a comparatively youthful one, but there are few which can show an equivalent rate of growth. In the last twenty years the world's production of oil has been quadrupled. All the tremendous advances that have been made in modern machine engineering would have been impossible without the aid of petroleum. It is undeniable that the tremendous strides made in transport and traction would never have been accomplished without the provision of the cheap and suitable fuels and lubricants that are the derivatives of crude petroleum. It would be difficult to envisage a world deprived of the 200 or more derivatives of modern refining.

Gentlemen, as the petroleum industry is one that places such great reliance on science and as it is one with an abnormal growth, I consider that we, as technologists, can claim much of the credit for this tremendous advance. The petroleum industry is now wedded to science and, provided that the union is a happy one, the progeny is progress.

I have again to record a year of progress so far as this Branch of the Institution is concerned. Our membership has increased and the attendance at our meetings continues to improve. The papers read at the meetings, as heretofore, covered a wide range

of subjects. Since the inception in 1928 no less than 32 papers have been read.

I consider that the parent institution realises more and more the value of these foreign branches. Situated as they are, actually in the producing countries, there will be a tendency for their proceedings to have a more essentially practical outlook, as compared with the more academic type that is liable to characterise the London proceedings. The combination of these two types is an ideal one for any learned society. With the object of closer co-operation, I think a proof of their increased interest lies in the fact that the chairmen of the various branches have recently been elected to a special committee to deal with liaison and allied subjects.

The parent institution are justified in considering 1933 as a red-letter year in their history. It marks the organisation by them of the World Petroleum Congress, which was held in London in July. This Congress was attended by approximately 1000 technologists from all parts of the world, and as one present I can testify to the excellence of the arrangements. It may perhaps be difficult to point to any concrete advantages from such a Congress, but the actual spirit of international co-operation which it engenders and the mutual interchange of ideas which it permits are alone full justification for a continuance of such gatherings.

I should like to record my indebtedness to the committee for all the aid they have given me, and should particularly like to mention Mr. Kirby. He assumed the duties of Honorary Secretary at short notice during Mr. Reid's absence on vacation. On his shoulders have fallen all the work connected with the organisation of this dinner.

I am sure that all present will join with me when I express our appreciation of the presence of His Excellency here to-night. His continued interest in our doings is a source of deep gratification to us.

I cannot conclude without making a specific reference to the services of Mr. A. Frank Dabell to the Trinidad Branch of the Institution. It was he and he alone who conceived the idea of the formation of a local branch, and it was due to his energy that this idea materialised. As one who served on the committee during his four years' occupancy of the chair, I can give him my full meed of praise for the time and trouble he expended.

As a member of the Council of the parent institution he has been, and continues to be, of incalculable value to us, and I am only too pleased to be given this opportunity of making public reference to his services.

In conclusion, I should like to refer to the fact that Mr. A. P. Catherall is probably leaving us in the near future. He is one who has always studied the interests of the petroleum industry and that of the Government absolutely impartially. The Government will be losing a valued servant and we an influential member of the Institution.

On behalf of the Trinidad Branch of the Institution of Petroleum Technologists, I thank you, sir.

"The Industries of Trinidad."

Mr. A. J. Ruthven-Murray, in proposing the toast of "The Industries of Trinidad," said: At the last two annual dinners reference was made to the world-wide depression. I am not prepared to state that this has now passed, for cocoa and copra are still very depressed, but industry as a whole is looking up and commodity prices in general are rising fast. For this improvement I believe we can, in a measure, give credit to President Roosevelt's National Recovery Act. Certainly this applies so far as our own industry is concerned. As a practical outcome of the depression many new minor industries have sprung up in our Colony, and some of these are a direct benefit to the health of the community. In particular I wish to mention the excellent fresh milk and cream which is now obtainable, a commodity which we cannot import. It must please us all to know that the water-supply scheme, so many years overdue, is at last well under way, for a good water supply is of paramount necessity to industry and for the personal needs of the community. The harbour scheme is one which has been under consideration for very many years, and is now approved. I am sure you will all join with me in wishing the harbour scheme all possible success, and may it be instrumental in increasing our production and exports. It will be a happy day when we see thousands of cases of grape-fruit and, I hope, avacado pears and possibly tomatoes being loaded into vessels alongside. It is satisfactory also to learn that our Colony is likely to have a surplus of revenue over expenditure amounting to £4000 on the year, and this in spite of the depression. However, we would like the surplus to be larger so that the tax on our beer and petrol could be less. Before sitting down, I must just say a word for the petroleum industry. It is the largest in the Colony—when viewed from the standpoint of export and placing money into circulation. The export of petroleum constitutes approximately 60 per cent. of the Colony's total, while the oil production of Trinidad was, on last year's figures, 17 per cent. greater than that of any other British oil-producing country.

Mr. J. Pendrich, in reply, said: The technologist, as a general rule, I believe, is denied the glamour—the financial glamour—if I may use the expression, certain other sections of industrialism are afforded. He pegs away at his task, striving for the utmost efficiency, and endeavouring to produce something new to science, and, here I shall take it upon myself to say, pursues his profession and applies it in the old honest method of industry. It is a noble and delightful characteristic.

In so far as the petroleum technologist is concerned he has, I should fancy, every reason to feel proud of his achievements, just as much as this Colony has reason to feel proud of her domain.

The oil industry, like any other, is subject to its ups and downs, subject to disagreeable visitation, and while the present market values do not produce remuneration as was forthcoming heretofore, it is no fault of the technologist.

Petroleum, I understand, can be produced in quantities. Petroleum, I know, is produced in its various grades of the highest quality, and when it comes to the matter of supplying bunkers and/or export cargoes, the most efficient is applied, and/or the most efficient craft employed, resulting in expeditious and satisfactory despatch to the ocean-going vessel.

With these qualifications this Colony, I am pleased to make the observation, ranks high in the esteem of commercial and shipping interests inside and outside of the Colony, and I, as President of the Trinidad Chamber of Commerce, as an individual and a member of the mercantile community, tender praise and thanks to you, good gentlemen, for what must obviously be an unbounded effort to foster industry as the only natural sure way to wealth.

"Our Guests."

Mr. A. Frank Dabell said: I have the honour to propose the toast of "Our Guests," and to couple the toast with the name of Colonel Evans, who needs no introduction in this or any other part of the Empire, for, at the Imperial College of Tropical Agriculture, Empire-builders have for years been trained by him.

I have some difficulty in referring to other guests, for our relations are somewhat involved, in that they, in a larger sense, are our hosts—and for the greater part, the members of the Institution of Petroleum Technologists, their guests.

The aim of our Institution, in particular, is the attainment of efficiency. At one time this meant prosperity—to-day efficiency, to our sorrow, means more unemployment.

It may interest your Excellency to know that, at the next monthly meeting of the technologists, the paper down for reading is one by Dr. De Verteuil—on malaria preventative measures—

for, as the history of the construction of the Panama Canal showed, without good health technical efficiency is unattainable.

Reference has been made to the World Petroleum Congress held in London this year, and, apropos of guests, I arrived just in time to attend the banquet given in the evening of the last day. The guest of honour was the Right Honourable Sir Godfrey Collins, the Secretary of State for Scotland, and he took us into his confidence and that of his Cabinet colleagues, by telling us that it had been decided to give such help to the petroleum industry, by obtaining oil from coal, that importation of petroleum would decrease gradually. The help being in the nature of exemption from excise duty of 8d. per gallon for 100,000 tons per annum—say £1,000,000, which, of course, is equivalent to our paying the subsidy.

It is equivalent, for instance, to His Excellency announcing to this gathering that a grant of 16 cents per gallon was to be made to the Principal of the Imperial College to permit him to hydrogenate the residue of sugar cane. Given the encouragement, the College might do it, but I do not think we need feel any anxiety on the part His Excellency will play.

Mr. G. Evans, in reply, said: It gives me great pleasure to respond on behalf of the guests. We all of us appreciate very greatly this opportunity of meeting so many men who are distinguished in the oil world.

The petroleum technologists are the brains of the industry, and on them depends the continuance of progress and research. It is a good augury for the industry of Trinidad, therefore, that such a flourishing branch exists in the Colony.

As you know, research is having a hard time of it just at present during this period of depression. A portion of the general public hold rather a short-sighted view and is inclined to think that money spent on research at the present time is a waste of money. I know that this is said of agricultural research, and I have no doubt it is also said of oil or of any other great industry. The argument is that already there is over-production, and with the existing glut why spend money on investigations that will merely lead to the production of more.

This matter was thoroughly debated at the meeting of the British Association for the Advancement of Science, which was held at Leicester last August. Sir Frederick Hopkins, the famous Cambridge bio-chemist and President of the Royal Society, who was presiding, summed it up in a nutshell when he declared that "science cannot go slow—it may change direction, but it must go forward." I think we all are agreed that it would be fatal to allow the spirit of scientific research to die down.

The general public perhaps do not really understand what is meant by research, and I should like therefore to quote Sir John Russell, the Director of the Rothamsted Agricultural Research Institute, who has put the matter very clearly. He says, in a recent publication : " Scientific investigations in agriculture are primarily for the purpose of obtaining information and will always be needed so long as farming continues. It is in times of difficulty that this information is most valuable to the farmers, as it enables them to change their methods rapidly and to alter their plans in accordance with rapidly changing conditions." If this is true for agriculture, I have no doubt that it equally applies to oil. We at the Imperial College of Tropical Agriculture have come more into touch with the oil industry lately. Our soil chemists have found much of interest in the investigations of your geologists, and quite recently one of our plant pathologists (Dr. H. R. Briton-Jones), who has been looking out for suitable materials for the production of a combined fungicide and insecticide, has collaborated with a considerable degree of success with the chief chemist of a well-known oil refinery in Trinidad. Exhaustive experiments have been undertaken, and these indicate that some of the residue of refineries possess properties admirably suited for this purpose. Research and its application to industry is supposed to be of advantage to both producer and consumer.

On behalf of my fellow guests I wish to thank you for a very pleasant evening and to hope for continued success to the Association of Petroleum Technologists in Trinidad.